RL-TR-94-196
Final Technical Report
November 1994

MICRO-TIME STRESS MEASUREMENT DEVICE DEVELOPMENT

Honeywell Inc.

Gary Havey, Steven Louis, and Steven Buska

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

Rome Laboratory
Air Force Materiel Command
Griffiss Air Force Base, New York

This report has been reviewed by the Rome Laboratory Public Affairs Office (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be releasable to the general public, including foreign nations.

RL-TR-94-196 has been reviewed and is approved for publication.

APPROVED: Roy F. Stratton

ROY F. STRATTON
Project Engineer

FOR THE COMMANDER: John J. Bart

JOHN J. BART
Chief Scientist, Reliability Sciences
Electromagnetics & Reliability Directorate

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	November 1994	Final Aug 89 - Jan 92

4. TITLE AND SUBTITLE

MICRO-TIME STRESS MEASUREMENT DEVICE DEVELOPMENT

5. FUNDING NUMBERS

C - F30602-89-D-0100, Task 1
PE - 64609F
PR - TSMD
TA - QB
WU - 02

6. AUTHOR(S)

Gary Havey, Steven Louis, and Steven Buska

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Honeywell Inc.
Systems and Research Center
10701 Lyndale Ave So.
Minneapolis MN 55420

8. PERFORMING ORGANIZATION REPORT NUMBER

N/A

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Rome Laboratory (ERSR)
525 Brooks Rd
Griffiss AFB NY 13441-4505

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

RL-TR-94-196

11. SUPPLEMENTARY NOTES

This effort was funded by the RAMTIP Office. The prime contractor is the IITRI Research Institute, 201 Mill St, Rome NY 13440. Rome Laboratory (see reverse)

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

This report describes the Micro-Time Stress Measurement Device (TSMD) developed and delivered under this contract. The Micro-TSMD is a microprocessor controlled device to read the installed environmental sensors and record their results in a non-volatile memory. It is contained in a hybrid package about 1 x 1.8 x 0.2 (inches), weighing less than an ounce. The TSMD contains sensors for temperature, mechanical vibration/shock, and DC voltage monitoring, including transients, and may be connected to external sensors. It requires external power.

This project was funded by the RAMTIP Program Office at WPAFB OH.

14. SUBJECT TERMS

Time Stress Measurement Device (TSMD), Sensors, Environmental data, Digital environmental recorder

15. NUMBER OF PAGES

90

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

11. (Cont'd)

Project Engineers: James A. Collins (initiating), Leonard J. Popyack, and Roy F. Stratton/ERSR/(315) 330-4205.

Accesion For	
NTIS CRA&I	☒
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution /	
Availability Codes	
Dist	Avail and / or Special
A-1	

TABLE OF CONTENTS

Subject				Page
	GOVERNMENT PREFACE			viii
	EXECUTIVE SUMMARY			1
1.0	INTRODUCTION			2
	1.1	Program Objective		2
	1.2	Program Scope		2
	1.3	Time Stress Measurement Device Background		2
	1.4	Previous Micro-TSMD Program		3
	1.5	Micro-TSMD Features		3
2.0	THEORY OF OPERATION			14
	2.1	Hardware		14
		2.1.1	Analog	15
		2.1.2	Power Regulation Electronics	15
		2.1.3	Shock Recorder	16
		2.1.4	Vibration Sensor	17
		2.1.5	DC Voltage and Temperature	17
		2.1.6	Transient Detection	17
		2.1.7	Digital Electronics	19
	2.2	Software Development and Data Reduction Techniques		20
		2.2.1	Redundancy Reduction and Parameter Extraction	20
		2.2.2	Reduction hardware Implementation	21
		2.2.3	Voltage Data Reduction Implementation	22
		2.2.4	Voltage Transient Data Reduction Implementation	23
		2.2.5	Temperature Data Reduction Implementation	23
		2.2.6	Vibration Data Reduction	25
		2.2.7	Shock Data Reduction	25
		2.2.8	Histogram Stress Data	26
3.0	APPLICATIONS OPTIONS			27
	3.1	External Battery Operation		27
	3.2	External Accelerometer		27
		3.2.1	Procedure for Using and External Accelerometer	27
	3.3	Using Extra A/D Channels		27
4.0	INPUT/OUTPUT DEFINITIONS			29
5.0	SOFTWARE OPERATION			34
	5.1	Configuration Instructions		34
	5.2	Using Menus		34
	5.3	Using the MAIN Menu		34
	5.4	Using MAINTENANCE LOG MENU		35
		5.4.1	Option 3 INITIALIZING text	35
		5.4.2	Option 1 VIEW	35
		5.4.3	Option 4 WRITE PROTECT	36
		5.4.4	Option 2 EDIT	37

TABLE OF CONTENTS (Concluded)

LIST OF FIGURES

Figure **Page**

LIST OF FIGURES (Concluded)

LIST OF TABLES

GOVERNMENT PREFACE

It became clear in the early 1980's that a device to measure and record the environmental stress on an electronic system while it was operating would be valuable; and, of course, logistic history and other information about a system would also be useful. The idea for the original Time Stress Measurement Device was triggered by a review of a Producibility, Reliability, Availability and Maintainability (PRAM) program at Battelle Institute in the early 1980's. That program - Stress Accumulation Indicator, PRAM Proj. 30580-01 - bears little resemblance to the Time Stress Measurement Device, but the aims were similar.

The Time Stress Measurement Device (TSMD) is a micro-processor controlled measurement and recording device that can record environmental parameters and logistic data, and is small enough to be used on aircraft. The emergence of microprocessors and non-volatile memory made the TSMD possible.

The original TSMD effort started in 1986 at Rome Air Development Center (RADC, now Rome Laboratory, RL) and was funded by Producibility, Reliability, Availability and Maintainability (PRAM) Office, the Generic Integrated Maintenance and Diagnostics Systems (GIMADS) Office, and Air Force Systems Command (through RADC laboratory director's funds). It measured a number of different environmental parameters (vibration, shock, temperature, voltage, and corrosion) and was originally flown in electronics bays on A-7 and A-10 aircraft. Modified versions have flown on several platforms and one is now flying on the B1-B. However, it is 6x3x1 1/4 inches and weighs about 3 pounds. A battery pack for 30 days operation weighs about 20 pounds.

This effort, Microminiature TSMD Development, started in 1987 with a proposal by RADC to an AFSC office at Andrews AFB which was then merged into the Reliability And Maintainability Technology Insertion Program (RAMTIP). Phase 1, design definition, was a dual award to Westinghouse and Honeywell to develop a prototype design for a micro -TSMD. Both companies presented developmental model hybrid devices. The Westinghouse effort is covered in RL-TR-92-82. The Honeywell report has not yet been published.

Phase 2 was awarded to IITRI with Honeywell as subcontractor, and is described in the main part of this report.

Twenty (20) preproduction prototypes about 2 x 1 x 0.2 inches and weighing less than an ounce were delivered in 1992 at the conclusion of the program. Original plans to build a production proto-type were dropped for lack of funding.

About half of the micro-TSMDs were delivered to Warren-Robins Air Logistic Center. Three were installed in RF amplifiers in ALQ-135 Line Replaceable Units (LRU's) intended for F-15 test aircraft at Eglin. For various reasons these TSMD's never flew.

Micro-TSMDs have also been loaned to other organizations. One TSMD was loaned to the Army. Four TSMDs have been loaned to the Navy. They will be used in the SLQ-32 (SLICK 32) shipboard EW system. Air Force Space Command will use two TSMDs to monitor the environment on mission critical remote tracking station equipment.

In addition, Honeywell obtained an export license and shipped two (not built with Air Force funds) to France in an attempt to develop an export business.

There are two follow-on efforts: Quick Reliability Assessment Tool (Quick RAT), and Fault Logging Using Micro-TSMD (neither is funded by the Technology Transition Office).

RAMTIP expended $1.49 million on this project (RAMTIP Project Number 8702). Phase 1 cost $419 K ($203 K to Westinghouse, and $216 K to Honeywell), and Phase 2 cost $1.074 million. The result was an advanced version of the TSMD which has seen relatively wide usage. Cost savings are indeterminate at this time, since usage continues, and savings are hard to quantify.

The support of Capt. Harry Johnson and Capt. Tony Moyers at WR-ALC/LYPRM, Robins AFB, GA (DSN 468-9474) has been extremely important for this project.

EXECUTIVE SUMMARY

This is the final report for the Micro-TSMD (Time Stress Measurement Device) program. It documents the results of a three year effort during which time a design evolved for a device packaged into a 1" X 2" X 0.2" hybrid flat pack configuration. The device was designed to be capable of measuring and digitally storing in nonvolatile memory, vibration, shock, temperature, dc voltage levels and voltage transients. Data compression algorithms are utilized in order to obtain maximum utilization of memory space. The device operates from a 5V supply, consumes 100 mW of power and has provisions for an external battery if it is desired to maintain the system real time clock as well as accumulate transportation shock data while the remaining system is silent. The data accumulated in the device is debriefed through an RS-232, 9600 baud output port to a terminal or personal computer. Debriefing requires no special external software.

The Micro-TSMD represents an advancement beyond a data-logger that only samples data based upon preprogrammed sample intervals. The Micro-TSMD resulting from this program processes data and in addition compresses the data and creates tables of the data for statistical analysis and will store data almost indefinitely allowing it to accumulate almost a life history for the system being measured.

The overall Micro-TSMD development program was divided into two parts. The first was the design definition phase that covered the period from 1988-1989 which was funded prior to the efforts conducted under this program. During this initial phase the system design and software definition evolved. This was followed by a sensor selection activity and material procurement for the digital section that was built. This program constituted the second phase of the micro-TSMD effort that started in 1989 and concluded in 1992. During this time the sensor interface electronics were designed and the sensor electronics were built. Additionally, 20K X 8 of program code was written for the TSMD to collect and compress measured data.

Hardware deliveries for the program were 20 preproduction units which were delivered by the program conclusion in 1992.

Section 1
Introduction

1.1 Program Objective

The objective of this program was to design, develop, test and deliver 20 Micro-Time Stress Measurement Devices (TSMD) packaged in a hybrid configuration measuring 1" X 2" X 0.20". These Micro-TSMDs were designed as preproduction units for potential production of larger quantities for insertion into fielded avionics line replaceable units (LRUs) or line replaceable modules (LRMs).

1.2 Program Scope

A Micro-TSMD design was developed and qualified which has thermal, vibration, shock, electrical voltage and voltage transient measuring and recording capabilities. Extensive laboratory testing of the Micro-TSMD hardware was conducted to verify its physical integrity, its data measurement and recording accuracy and its ability to perform in a military environment. Twenty Micro-TSMD preproduction prototypes suitable for mounting on circuit cards that could be flown in operational avionics systems were delivered at the conclusion of the program in 1992.

1.3 Time Stress Measurement Device Background

Some of the major stress sources that contribute to the failure of electronic equipment are thermal cycling, shock, vibration, internally generated heat and system voltage transients. The cumulative effect of these stresses can damage parts and cause failure of electronics systems. Current parameters used to measure and quantify reliability, such as mean time between failure (MTBF) are measured in terms of calendar time, operating time, sorties and operating cycles. When failures occur they are the culmination of the effect of stresses on the equipment but very little is known about the dynamics of the actual stress history to which the equipment was actually exposed before failure. The TSMD is a measurement and recording device that can be used for stress history recording. The TSMD measures and records, at its mounted location, or through remote sensors, the key stress parameters in a specialized database format for later retrieval.

A TSMD can provide many payoffs in the critical areas of system readiness and logistics supportability. The accumulated stress parameters can provide more accurate predictions of the remaining life of fielded electronics than simply calendar time recording. TSMDs can also be used as a tool for helping to develop prognostic maintenance schedules, complimenting the troubleshooting talents of highly skilled maintenance personnel, reducing the number of spares required and permitting more complete utilization of the inherent life of all system components.

TSMDs can also be used as a tool for warranty verification. Another very important payoff is the potential use of the TSMD stress data with integrated diagnostics/built-in test data (Smart BIT, Project Forecast II) to help identify and interpret failures which are environmentally sensitive and result in Retest Ok (RETOK) and Cannot Duplicate (CND) maintenance events which may account for up to 60% of the maintenance action in some systems.

Use of the TSMD will permit the creation of a specialized database of environmental exposure and maintenance data for each individually serial numbered board with a hybrid Micro-TSMD throughout its operational life. Information of this type has never been captured and systematically stored at the circuit board level previously and is greatly needed for improved logistics support.

1.4 Previous Micro-TSMD Program

Prior to the start of this Micro-TSMD Development program Honeywell was under contact for the Micro Time/Stress Measurement Device Design Definition Program (August 1988 to March 1989). Under this contract a number of limited capability prototype Micro TSMDs, called Interim TSMDs were fabricated for customer demonstration purposes. This design which was later improved upon served as the basis for the Micro TSMD.

1.5 Micro-TSMD Features

The Micro-TSMD is a hybrid microelectronic device capable of measuring and digitally storing, in nonvolatile memory, its exposure to vibration, shock, temperature, dc voltage fluctuations and voltage transients. It is capable of executing data compression algorithms to obtain maximum utilization of its memory space for collecting stress data. In addition the Micro-TSMD can store a maintenance history of the equipment it is used to measure. Hardware features of the Micro-TSMD include the following:

- Internal piezoelectric accelerometer for sensing vibration and shock perpendicular to the plane of the hybrid (an external accelerometer can replace the internal accelerometer as an external sensor source)

- Internal temperature sensor (an external temperature sensor can replace the internal temperature sensor as an external sensor source)

- Three ranges of voltage transient capturing.

- Internal real time clock (this function requires an external battery or power source to maintain operation during system shut down)

- Mechanical shock counting when the Micro-TSMD is not powered by a host. This function requires an optional battery power source external to the hybrid.

- DC voltage measurement

- RS-232, (0 to 5 V), 9600 baud interface to terminal , with an on/off flow control algorithm. No special external software is required to readout or setup the Micro-TSMD.

- 5 V ±10% requiring 100 mW of power

- –55°C to +125°C operation

- Package is 1" x 2" x 0.2", 74 lead metal flat pack

The Micro-TSMD has several features which make it a very versatile tool. It has the ability to store large amounts of environmental and physical data in a format that requires relatively little memory space. Additionally, data collection is not limited to internally mounted sensors since externally accessible analog channel inputs may be used to accept data from other sensors while still utilizing the system software processing capabilities. Portions of the internal circuitry may also be used with external sensors. For example, the anti-aliasing filter may be used in conjunction with an external accelerometer and charge amplifier.

Since the Micro-TSMD is designed to be a low power device, full battery operation is possible. Two battery ports and internal automatic selection switches allow the Micro-TSMD to be fully or partially operated on battery power. The Shock Counter and Real Time Clock using separate battery backup can be maintained in the operating mode in the absence of the main system power.

Input power protective circuitry allows the Micro-TSMD to be powered by unfiltered voltage sources and still record valid data.

Figure 1-1 shows a functional block diagram of the Micro-TSMD. The dotted line separates the analog portion which is on the left from the digital portion which is on the right.

The physical layout of the components of the Micro-TSMD hybrid is shown in Figure 1-2. Here the identified components on the left represent the digital circuitry as identified in the block diagram. The schematic for this digital circuitry is shown in Figure 1-3. The components identified in the hybrid layout are identified in the parts lists of Tables 1-1A and 1-1B.

Figure 1-4 shows the hybrid physical layout with the analog circuitry components identified. It represents the right half of Figure 1-2. Figure 1-5 shows the schematic of the analog circuitry. The parts lists of Tables 1-2A and 1-2B identify the analog circuitry components.

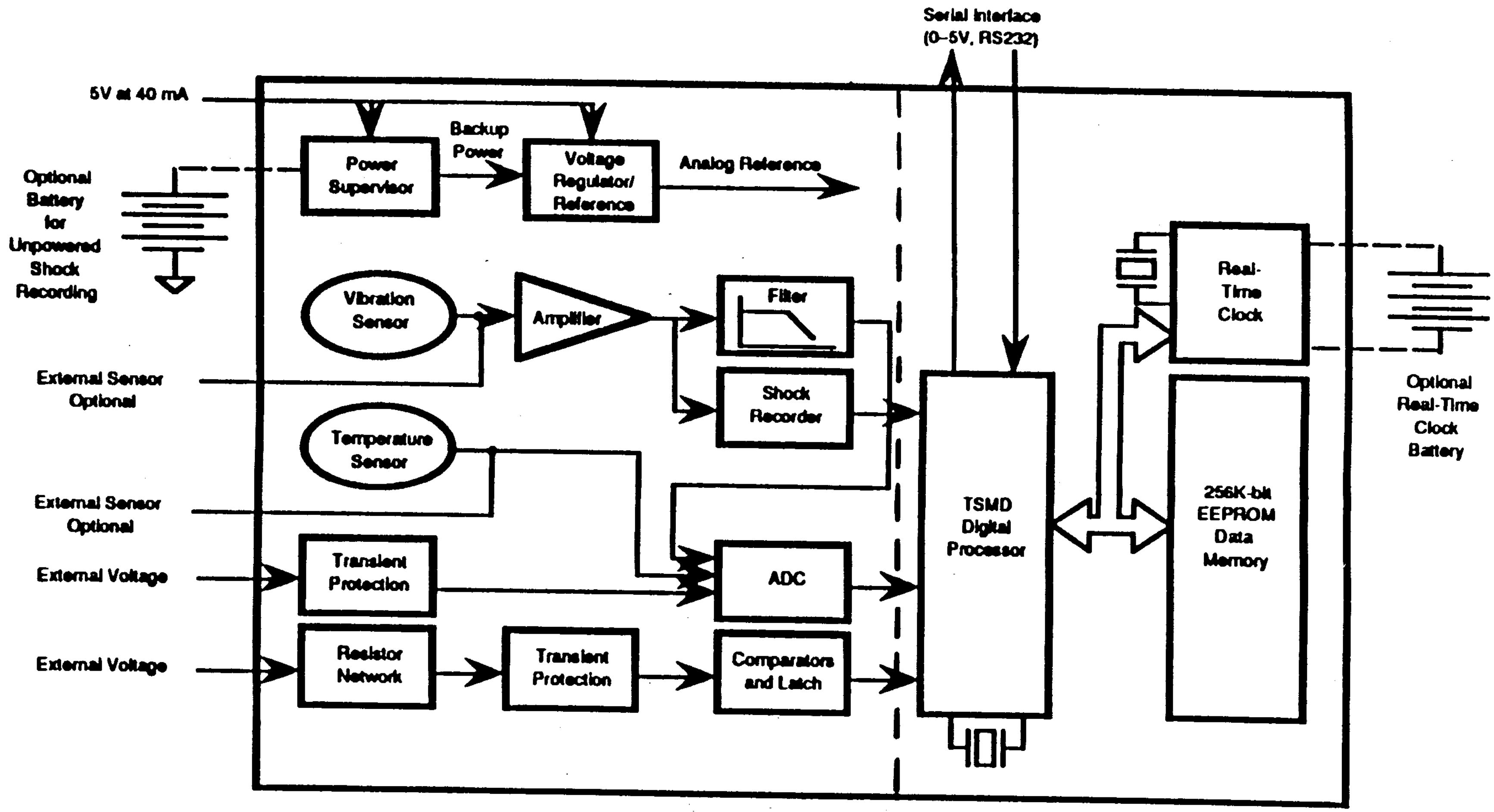
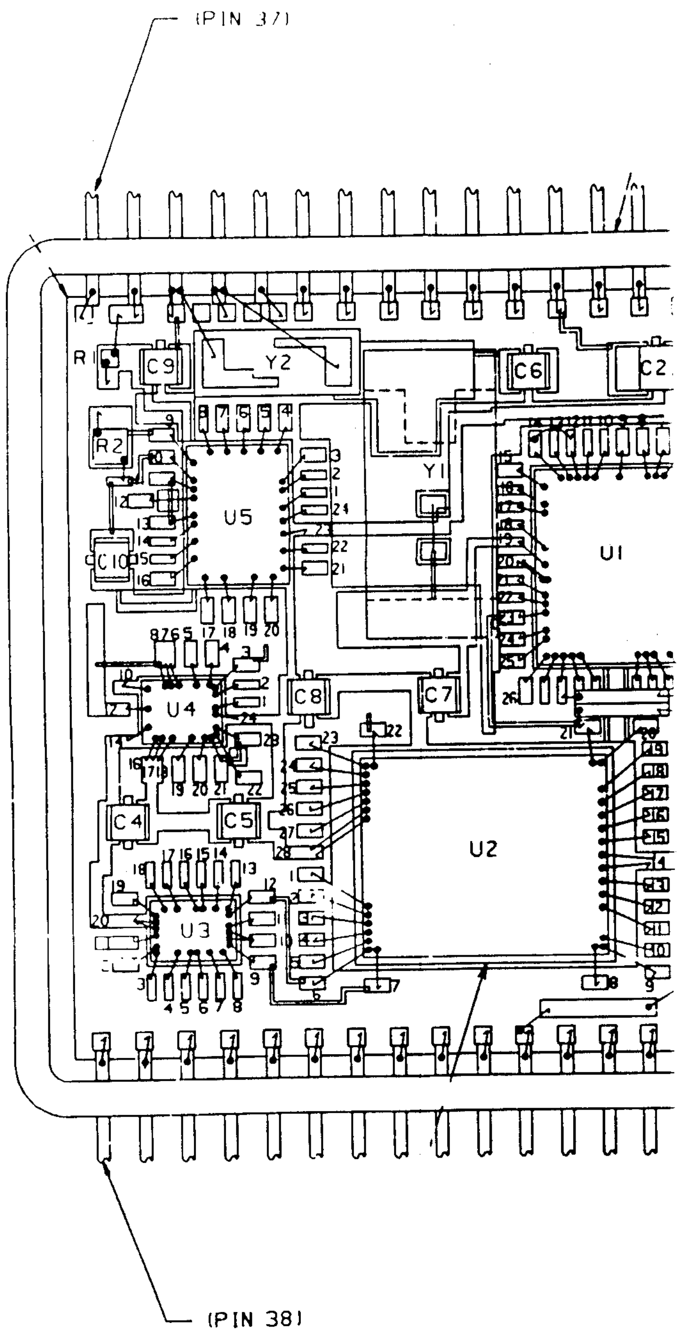
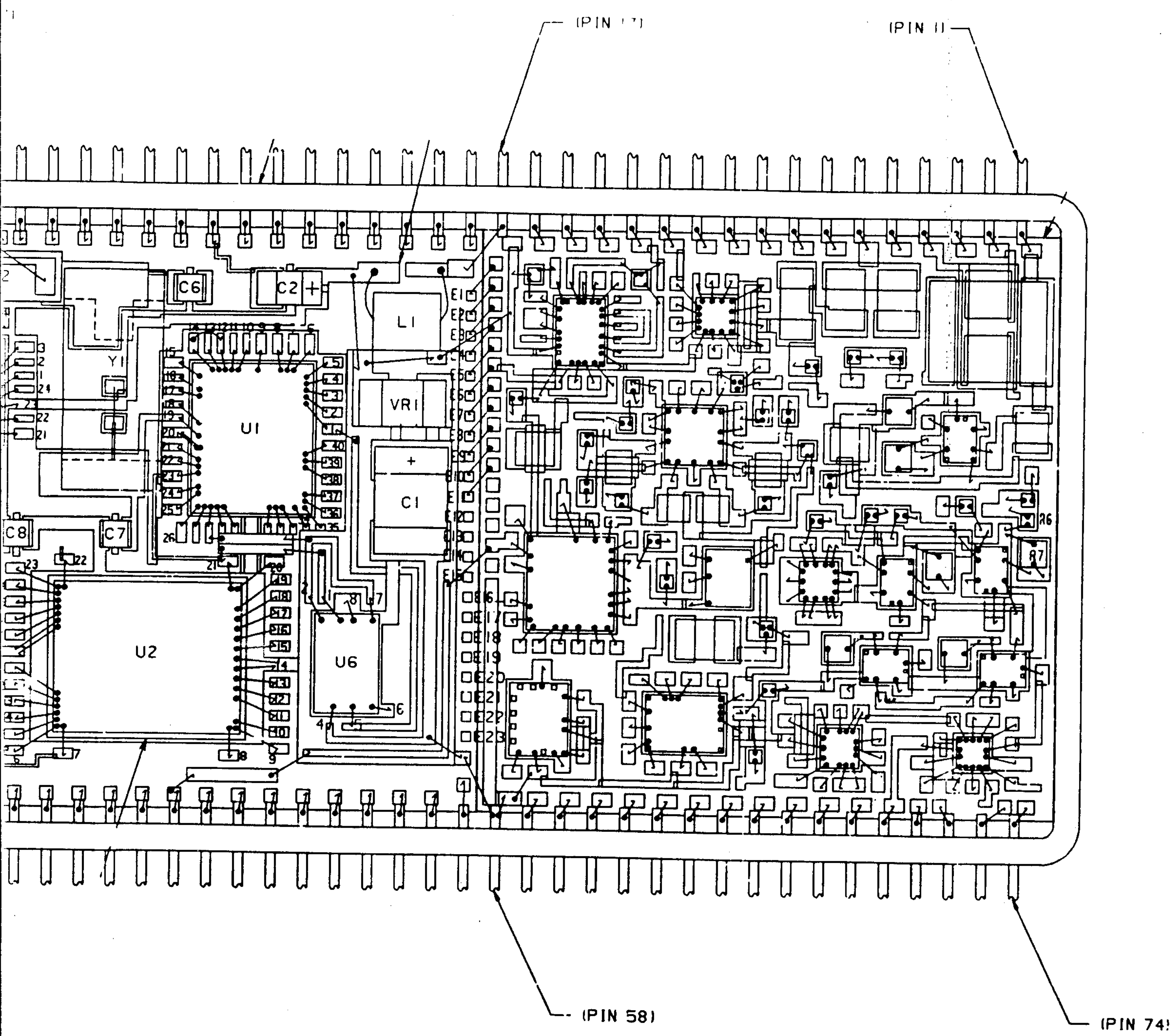


Figure 1-1. Block Diagram of the Micro-TSMD

1



I



VIEW SHOWN WITHOUT COVER (FIND NO. 3)

Figure 1-2. Micro TSMD Hybrid Layout

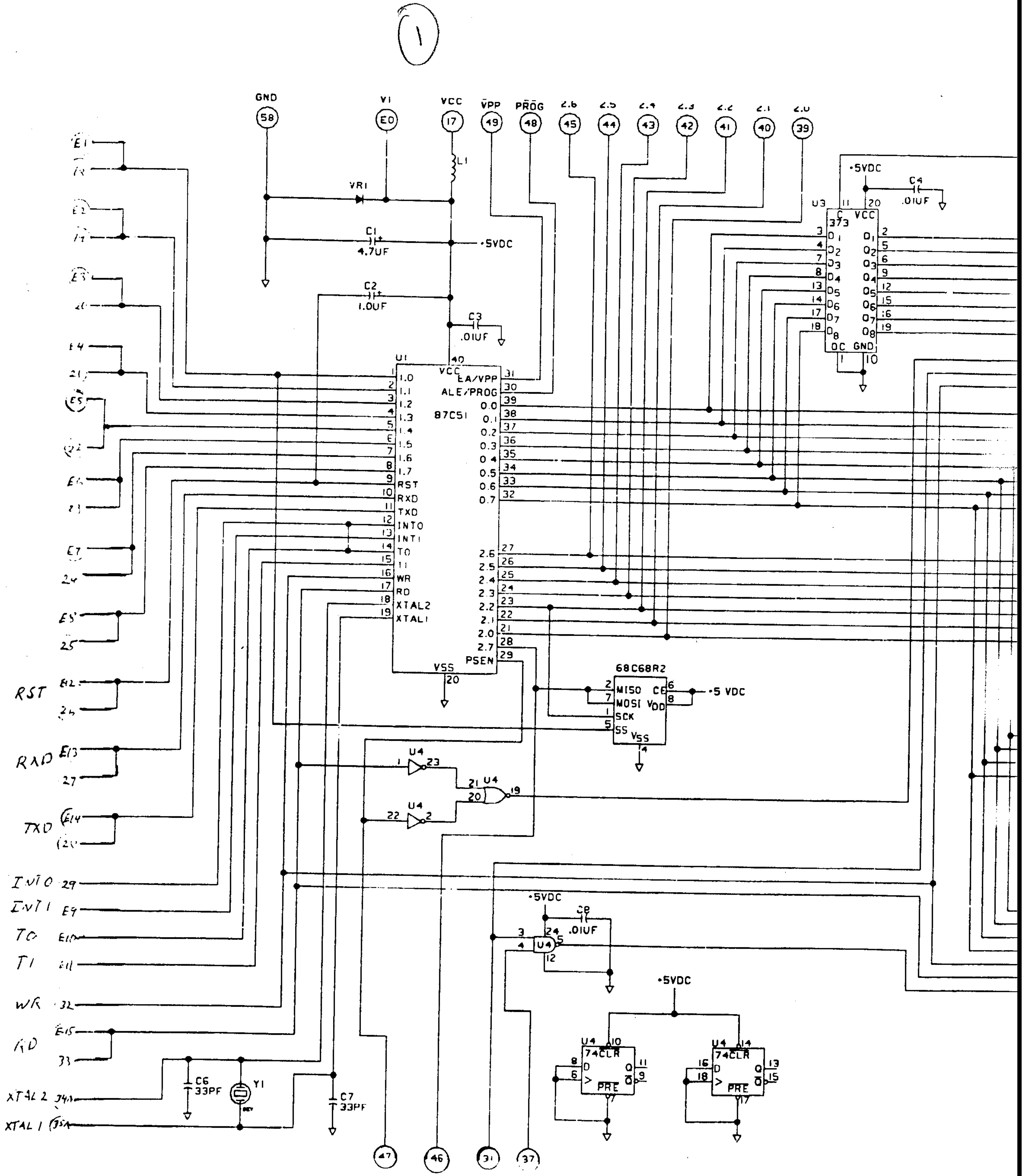
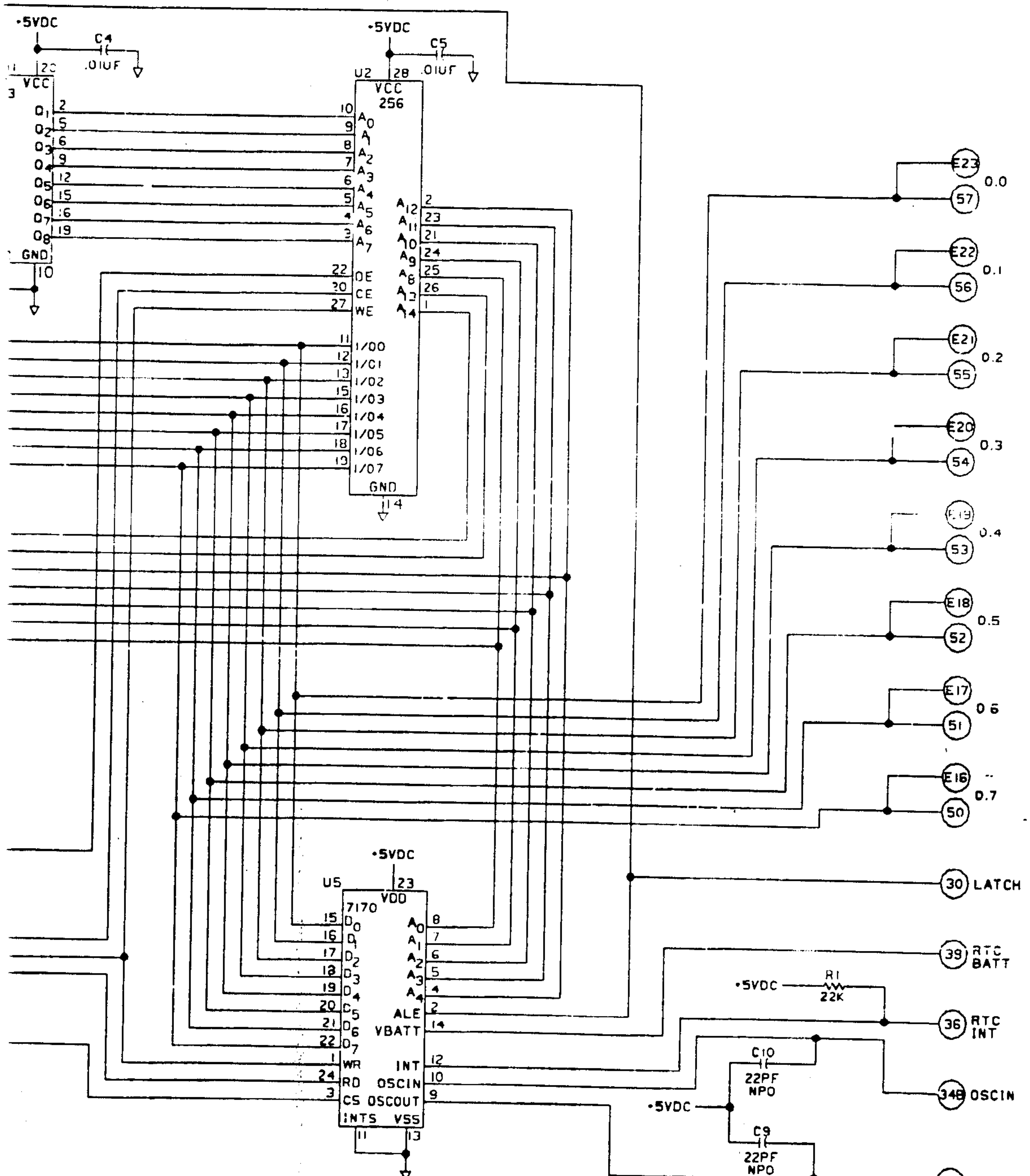


Figure 1-3. Digital Circuitry Schematic

②



+5VDC
C4
.01UF
VCC
GND
+5VDC
C5
.01UF
U2
VCC
256
OE
CE
WE
GND
E23
57
0.0
E22
56
0.1
E21
55
0.2
E20
54
0.3
53
0.4
E18
52
0.5
E17
51
0.6
E16
50
0.7
+5VDC
U5
7170
VDD
ALE
VBATT
WR
INT
RD
OSCIN
CS
OSCOUT
INTS
VSS
30 LATCH
39 RTC BATT
+5VDC
R1
22K
36 RTC INT
C10
22PF
NPO
34B OSCIN
+5VDC
C9
22PF
NPO
35B OSCOUT

/ Schematic

HONEYWELL INC.	CONTRACT NUMBER MFP U1803	CONT CL A	CHNG CONT NO UNRELEASED	CAGE CODE 94580	LIST NUMBER PL10130164-102	REV. LTR 0002	REV. DATE 90/04/05
UNRELEASED			LIST TITLE HYBRID ASSEMBLY - TSMD			SHEET NO 1	

	FIND NO	QTY REQD	CAGE CODE	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	REMARKS	CODES SCA1
U	1	1	94580	10130163-101	NETWORK, THICK FILM - TSMD		A
U	2	1	00000	FB100200EC0J2	FLATPACK	AEGIS INC	T
U	3	1	00000	DC-68	HYBRID LID	DEVICE CLOSURE	T
U	4	1	00000	87C51	MICRO COMPUTER	U1 INTEL	T
U	5	1	00000	28C256	MEMORY	U2 SEEQ	T
U	6	1	00000	54HC37*	MICROCIRCUITS	U3 NATIONAL	K
U	7	1	00000	54HC7074	LOGIC GATES	U4 NATIONAL	K
U	9	1	00000	CX-AT-11.0592MHZ	CRYSTAL	Y1 SATAK	T
U	9	1	81349	CWR06MA106KM	CAPACITOR	C1	K
	10	1	81349	CWR06FA105MP	CAPACITOR	MIL-C-55365/04 1MPF 10V C2	K
U	11	2	00000	500R11N330JW4	CAPACITOR	C6,7 SPRAGUE	T
U	12	5	00000	500R11B103KN4	CAPACITOR	C3,4,5,7,8 SPRAGUE	T
	13	AR	94580	MC8247-04	EPOXY, SILVER CONDUCTIVE		M
	14	AR	94580	MC9007-01	EPOXY,ADHESIVE		M
	15	REQD	94580	PC13463-01	EPOXY DIE BONDING		F
	16	REQD	94580	PC13471-01	ULTRASONIC BONDING,GOLD		F
	17	AR	94580	MC8249-02	WIRE, GOLD	1 MIL	M
	18	REQD	94580	PC29100-02	SPEC,ELECTROSTATIC		F
	19	REQD	94580	PC13460-02	CLEANING		F
	20	REQD	94580	DR16549	LIST - ESD SENSITIVITY LEVEL		M

Table I-1A. Digital Hybrid Components

HONEYWELL INC.	CONTRACT NUMBER HFP W1803	CONT CL A	CHNG CONT NO UNRELEASED	CAGE CODE 94580	LIST NUMBER PL10138164-102	REV. LTR 0002	REV. DATE 90/04/05
UNRELEASED			LIST TITLE HYBRID ASSEMBLY - TSMD			SHEET NO 2	

	FIND NO	QTY REQD	CAGE CODE	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	REMARKS	CODES SCAI
	21	REQD	94580	PC13478-01	SEALING, HERMETIC,		F
	22	AR	94580	MC6653-01	INK, BLACK		M
	23	REQD	96906	MIL-STD-130	IDENTIFICATION MARKING OF U.S. MILITARY PROP	(PC13440-01)	J
	24	REQD	96906	MIL-STD-883C	TEST METHODS		J
U	25	1	00000	ICM7170	CLOCK	U5 INTERSIL	T
U	26	1	94580	MSTF-2-S-H-22K-X	RESISTOR	R1 22 K 1% SEMIFILM	T
U	27	2		500R11N220JV4	CAPACITOR	C9,10 22 PF 1% SPRAGUE	T
U	28	1	94580	WSFX-000-2205-BK	RESISTOR	R2 22 M	K
U	29	1	94580	10143733-101	HYBRID ASSEMBLY - TSMD ANALOG		A

first used on HG1106AA01
CODE S S=AD Standard Part Manual Part
CODE C V=Vendor Item--see source or specification control drawing
CODE A Approval for use D=D&E Build P=Production Build A/space=All producing facilities L=Limited
CODE I Item code:

A-Assembly	G-GFE	N-Drawing
B-Process Piece Part	H-Interconnect Diagram	P-Piece Part, Non Std Part or Purchased Piece Part
C-Schematic Diagram	J-Govt or Ind Std Spec	R-Software X-Non Controlled Part
D-Device	K-Govt or Ind Std Part	S-Source/Spec Cont Item Y-System
E-Engineering Spec	L-Govt or Ind Std Matl	T-Miscellaneous Z-Non Controlled Assy
F-Non Process Spec	M-Non Material Spec	W-Wiring List

All items in "( )" are for reference only DNXX - Dwg Note No.

Table 1-1B. Digital Hybrid Components

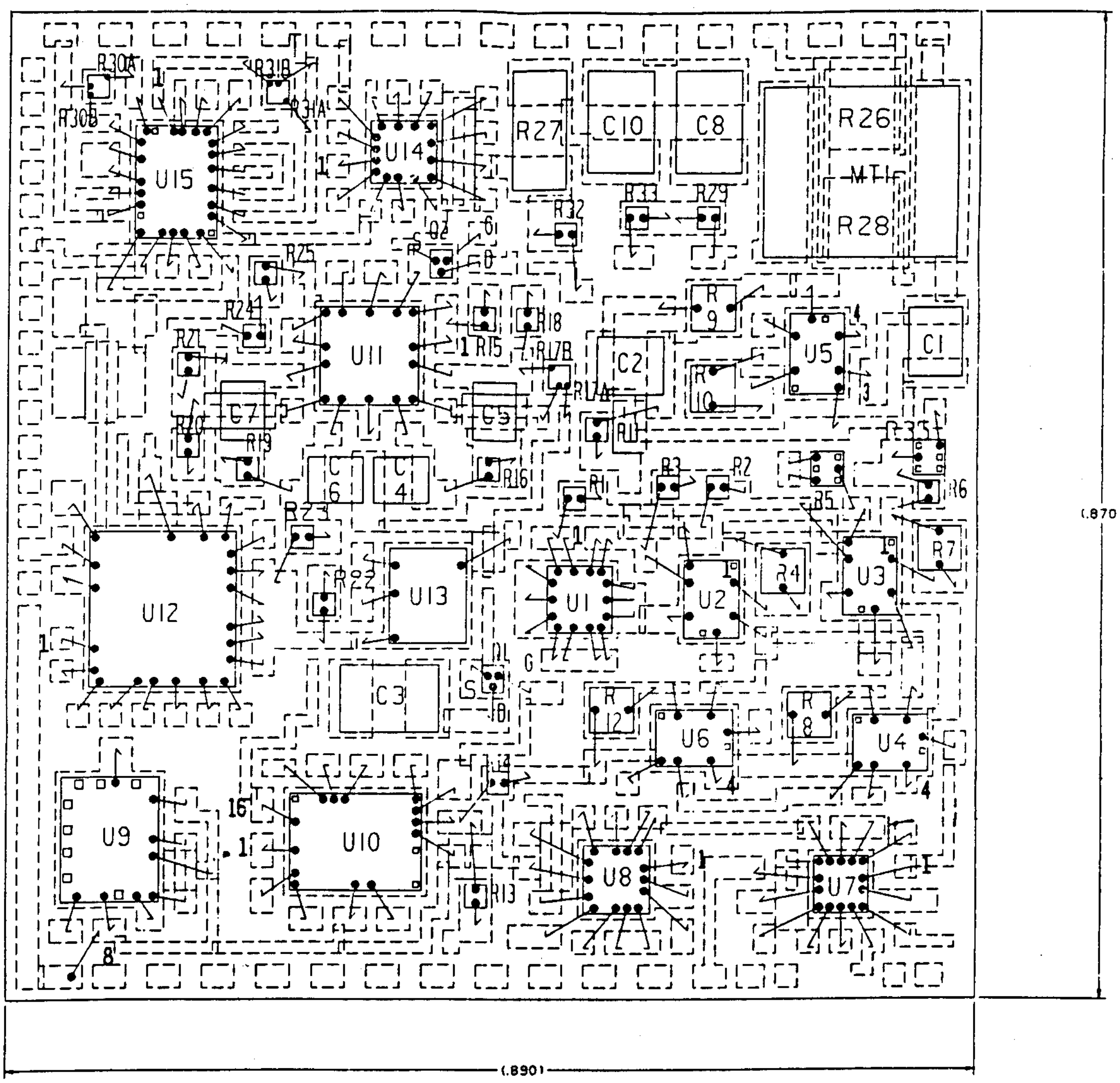


Figure 1-4. Analog Hybrid Layout

1

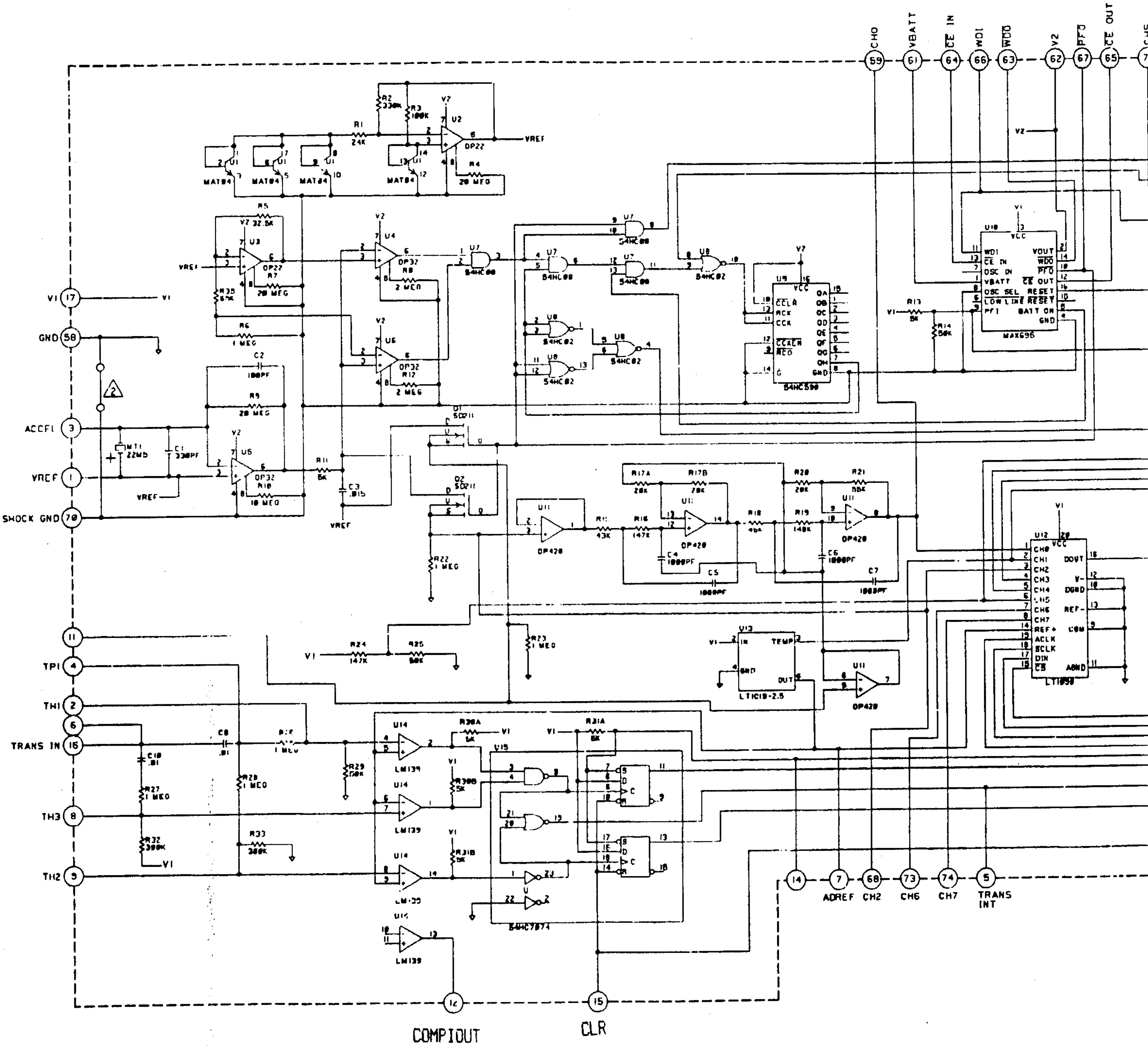
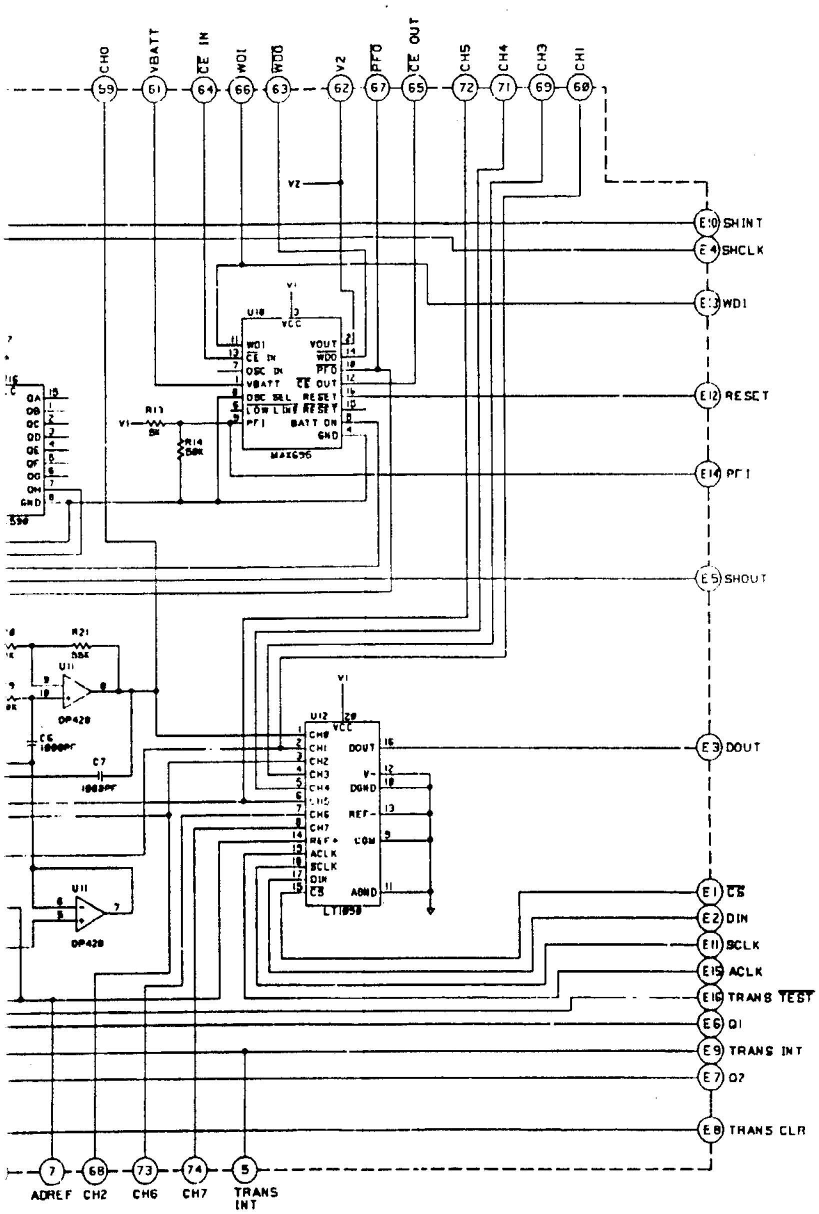


Figure 1-5. Analog Circuit Schematic

2


CH0
VBATT
CE IN
WDI
WDO
V2
PFO
CE OUT
CH5
CH4
CH3
CH1
59
61
64
66
63
62
67
65
72
71
69
60
V2
U10
VCC
WDI
CE IN
OSC IN
VBATT
OSC SEL
LOW LINE
PFI
VOUT
WDO
PFO
CE OUT
RESET
RESET
BATT ON
GND
MAX696
R13
R14
V1
R21
U11
OP420
C6
C7
U12
VCC
CH0
CH1
CH2
CH3
CH4
CH5
CH6
CH7
REF+
ACLK
SCLK
DIN
CS
DOUT
V-
DGND
REF-
COM
AGND
LT1090
U11
OP420
E10 SHINT
E4 SHCLK
E3 WDI
E12 RESET
E14 PFI
E5 SHOUT
E3 DOUT
E1 CS
E2 DIN
E11 SCLK
E15 ACLK
E16 TRANS TEST
E6 Q1
E9 TRANS INT
E7 Q2
E8 TRANS CLR
7
68
73
74
5
ADREF
CH2
CH6
CH7
TRANS INT

ic

HONEYWELL INC.	CONTRACT NUMBER HFP W1803	CONT CL A	CHNG CONT NO UNRELEASED	CAGE CODE 94580	LIST NUMBER PL10144481-101	REV. LTR 0002	REV. DATE 90/09/19
UNRELEASED			LIST TITLE HYBRID ASSEMBLY, MICRO-TSMD ANALOG			SHEET NO 1	

	FIND NO	QTY REQD	CAGE CODE	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	REMARKS	CODES SCAI
U	1	1		10144480-101	NETWORK, THICK FILM -TSMD ANALOG		A
U	2	1		MAT04NBC	MICROCIRCUIT, DIE	U1	P
U	3	2		OP226BC	MICROCIRCUIT, DIE	U2, U3	P
U	4	3		OP326BC	MICROCIRCUIT, DIE	U4, U5, U6	P
U	5	1		54HC08	AND GATE	U7	K
U	6	1		54HC02	MICROCIRCUIT, DIE	U8	P
U	7	1		54HC590	MICROCIRCUIT, DIE	U9	P
U	8	1		MAX691C/D	MICROCIRCUIT, DIE	U10	P
U	9	1		OP420NBC	MICROCIRCUIT, DIE	U11	K
U	10	1		LT1090	MICROCIRCUIT, DIE	U12	P
U	11	1		LT1019-2.5	VOLTAGE REGULATOR, CHIP	U13, 2.5V REF	P
	12	1		LM139	QUAD COMPARATOR	U14	T
U	13	1		54HC7074	LOGIC GATES	U15	K
U	14	1		22MS	ACCELEROMETER	MT1	P
	15	1		10052398-101	RESISTOR,CHIP,FIXED	R27, 1MEG OHM	B
U	16	1		10065303-319	CAPACITOR, CHIP, FIXED	C1, 330 PF	V S
	17	1		10137664-113	CAPACITOR	C2, 100 PF	V S
U	18	1		10065304-319	CAPACITOR, CHIP, FIXED	C3, .015 UF	V S
	19	4		10137663-105	CAPACITOR	C4-C7, 1000 PF	V S
	20	2		10065304-317	CAPACITOR, CHIP, FIXED	C8, C10, .01 UF	V S
U	21	2		SD211	MICROCIRCUIT, DIE	Q1, Q2	P
U	22	1		WSFM-045-24001F	RESISTOR, CHIP	R1, 24K OHM	P
U	23	2		WSFM-045-33002F	RESISTOR, CHIP	R2, R27, 330K OHM	P
U	24	1		WSFM-045-10002F	RESISTOR, CHIP	R3, 100K OHM	P
U	25	3		WSFX-049-20004K	RESISTOR, CHIP	R4, R7, R9, 20MEG OHM	P

Table 1-2A. Analog Hybrid Components

HONEYWELL INC.	CONTRACT NUMBER HFP W1803	CONT CL A	CHNG CONT NO UNRELEASED	CAGE CODE 94580	LIST NUMBER PL10144481-101	REV. LTR 0002	REV. DATE 90/09/19

UNRELEASED — LIST TITLE: HYBRID ASSEMBLY, MICRO-TSMD ANALOG — SHEET NO 2

	FIND NO	QTY REQD	CAGE CODE	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	REMARKS	CODES SCAI
U	26	2		WCTR-101-13002F	RESISTOR, CHIP	R5, R35, 65K OHM, CT	P
U	27	3		WSFM-045-10003F	RESISTOR, CHIP	R6, R22, R23, 1MEG OHM	P
U	28	2		WSFX-048-20003K	RESISTOR, CHIP	R8, R12, 2MEG OHM	P
U	29	1		WSFX-049-10004K	RESISTOR, CHIP	R10, 10MEG OHM	P
U	30	2		WSFM-045-50000F	RESISTOR, CHIP	R11, R13, 5K OHM	P
U	31	3		WSFM-045-50001F	RESISTOR, CHIP	R14, R25, R29, 50K OHM	P
U	32	1		WSFM-045-43001F	RESISTOR, CHIP	R15, 43K OHM	P
U	33	2		WSFM-045-14702F	RESISTOR, CHIP	R16, R24, 147K OHM	P
U	34	1		MSTF-3-S-N-40K-01	RESISTOR, CHIP	R17, 40K OHM	P
U	34	ALTN		WSFM-045-20001F	RESISTOR, CHIP	R17, USE 2 20K OHM	P
U	35	1		WSFM-045-45001F	RESISTOR, CHIP	R18, 45K OHM	P
U	36	1		WSFM-045-14002F	RESISTOR, CHIP	R19, 140K OHM	P
U	37	1		WSFM-045-20001F	RESISTOR, CHIP	R20, 20K OHM	P
U	38	1		WSFM-045-55001F	RESISTOR, CHIP	R21, 55K OHM	P
U	40	2		WCTR-101-10001F	RESISTOR, CHIP	R30, R31, 10K OHM	P
U	40	ALTN		WSFM-045-50000F	RESISTOR, CHIP	R30, R31, 5K OHM	P
U	41	2		WSFM-045-30002F	RESISTOR, CHIP	R32, R33, 300K OHM	P
	42	AR		MC8247-04	EPOXY, SILVER CONDUCTIVE		M
	43	AR		MC9007-01	EPOXY,ADHESIVE		M
	44	REQD		PC13463-01	EPOXY DIE BONDING		F
	45	REQD		PC13471-01	ULTRASONIC BONDING,GOLD		F
	46	AR		MC8249-02	WIRE, GOLD	.001 DIAMETER	M
	47	REQD		PC29100-02	SPEC,ELECTROSTATIC		F
	48	REQD		PC13460-02	CLEANING		F
	49	REQD		DR16549	LIST ESD SENSITIVITY LEV		M

Table 1-2B. Analog Hybrid Components

Section 2
Theory of Operation

2.1 Hardware

The Micro-TSMD hardware as shown in the previous section is divided into two parts; an analog section and a digital section as shown previously in Figure 1-2. This separation is physical as well as conceptual as the two hybrid substrates are mechanically mounted and electrically interconnected to form the complete device. The two halves communicate over bonded interconnections. These connections are internal and permanent. Some of these however are available externally and can be monitored via Micro-TSMD output pins. Table 2-1 describes the 16 internally available digital edge connections. Thirteen are actually bonded to the analog "edge" connections.

Edge #	Pin Out #	Title	Functional Description
1	None	CS	Chip Select Input; A logic low on this input enables data transfer to and from the A/D converter
2	None	DIN	Data Input; The A/D configuration word is shifted into this input.
3	None	DOUT	Digital Data Output; The A/D conversion result is shifted out of this output.
4	None	SHCLK	Shock counter line that allows the microcontroller to advance the shock count while monitoring the most significant bit to determine the number of shocks encountered when the unit was in the battery mode.
5	None	SHOUT	Represents the state of the most significant bit of the shock counter when the Micro-TSMD is not in battery mode.
6	None	Q1	Output of one of the flip-flops used to indicate that a transient has been encountered.
7	None	Q2	The second transient detection flip-flop.
8	15	TRANS CLR	Clears the two transient detection flip-flops.
9	5	TRANS INT	Interrupt line that informs the microcontroller that a transient has been encountered.
10	None	SHINT	Interrupt line that informs the microcontroller that a shock has been encountered.
11	None	SCLK	Shift Clock Frequency, This clock synchronizes the A/D converter serial data transfer.
12	None	RESET	Resets the state of the power supervision circuitry
13	66	WDI	Watch Dog Interrupt
14	None	PFI	Power Fail
15	None	ACLK	A/D Conversion clock; This clock controls the A/D conversion process.
16	14	TRANS TEST	Transient test; allows the built in test function to clock in logic low to both of the transient flip-flops.

Table 2-1. Internally Connected Analog-to-Digital Edge Connections

2.1.1 Analog

The signal processing analog shown in Figure 2-1 is listed below and is partitioned into four distinct functions, each relatively independent of each other:

- Shock recorder,
- Vibration sensor,
- DC voltage and temperature measurement,
- Transient detection.

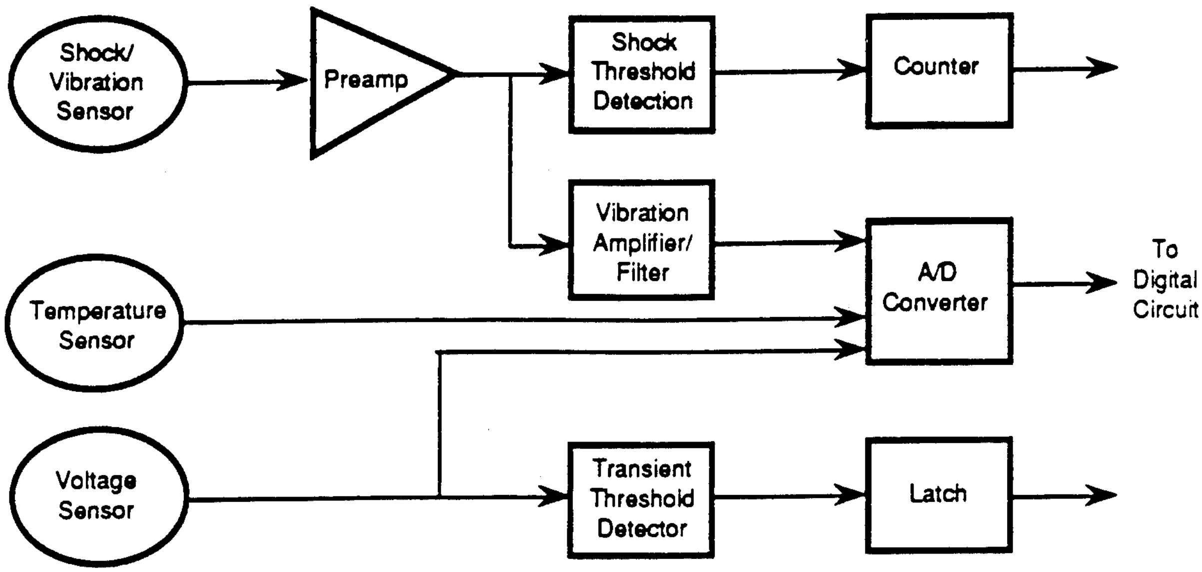


Figure 2-1. Micro-TSMD Analog Block Diagram

In addition to the analog signal processing electronics the power regulation electronics was also made part of the analog system design. It is described in Section 2.1.2.

2.1.2 Power Regulation Electronics

The Power Regulation Electronics block diagram is shown in Figure 2-2. The Micro-TSMD is protected from external voltage spikes on the power bus. Internal power regulation and switching, control monitoring modes and power consumption based on whether the Micro-TSMD is in the battery mode or regular power mode. The Micro-TSMD operates in the battery mode when the voltage on Pin 61 (Vbatt) is higher than the voltage on Pin 17 (Power In). In the battery mode, the shock counter circuitry and the real time clock are the only sections with power. The power specifications for the different modes are given in Section 6.

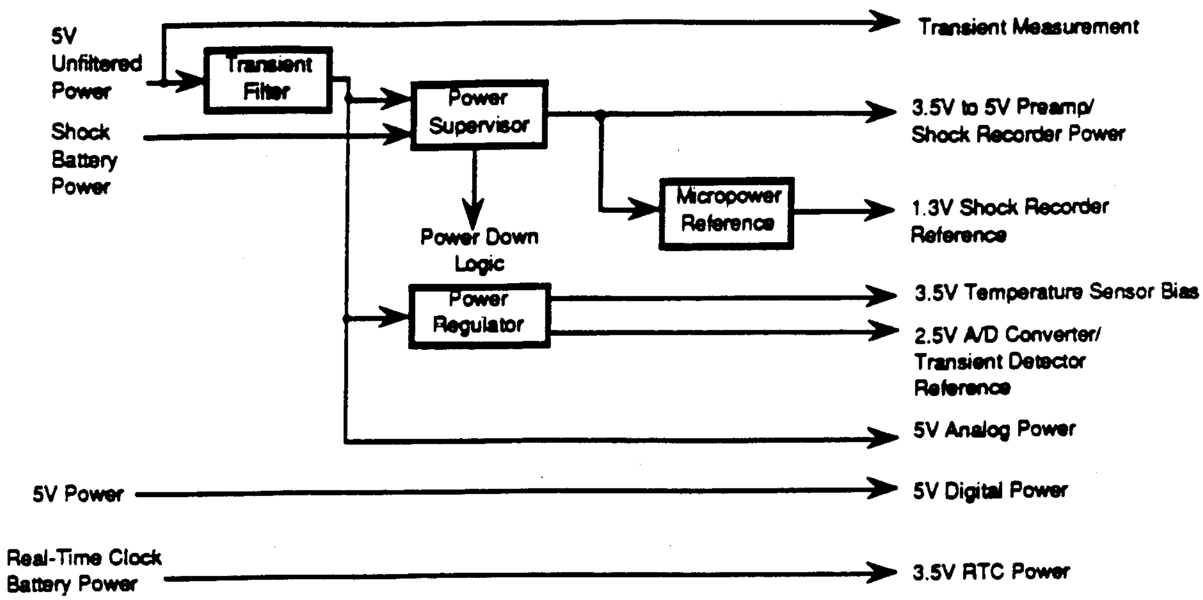


Figure 2-2. Power Regulation Electronics

2.1.3 Shock Recorder

The Micro-TSMD comes equipped with a shock counter shown in Figure 2-3 that counts the number of shocks above 3 G's. The shock counter will operate when the unit is operating under battery power. The counter will count up to a total of 127 shocks maximum. Any number of shocks above 127 will not be counted. The shock counter will not operate under main power. In this mode shock data will be sent directly to the processor via an interrupt line (For processing).

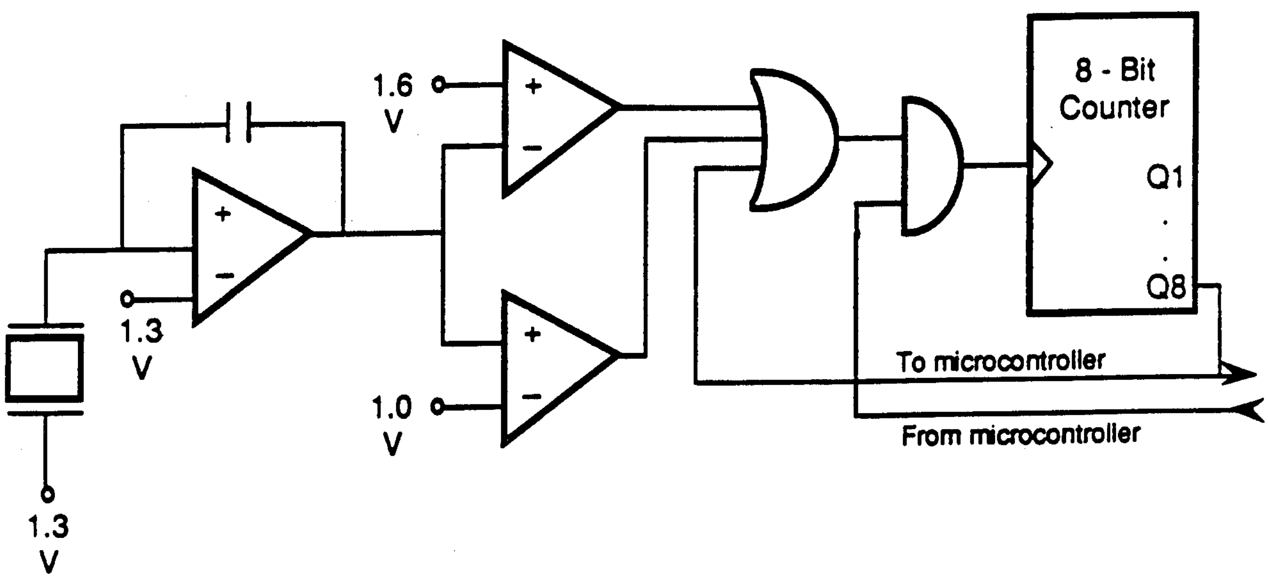


Figure 2-3. Shock Recording Circuitry

2.1.4 Vibration Sensor

The vibration sensing circuit is shown in Figure 2-4. The circuit begins at the accelerometer, which uses VREF (Pin 1) as reference ground. the accelerometer signal connects to a charge amplifier to change units from picocoulumbs per G to millivolts per G. The accelerometer signal is buffered and connected to an anti-aliasing filter which contains a simple RC circuit at its input and a second-order active buffered filter network at its output. This second-order filter can be used in conjunction with an external accelerometer and charge amplifier by connecting the external accelerometer to the appropriate A/D channel input connections.

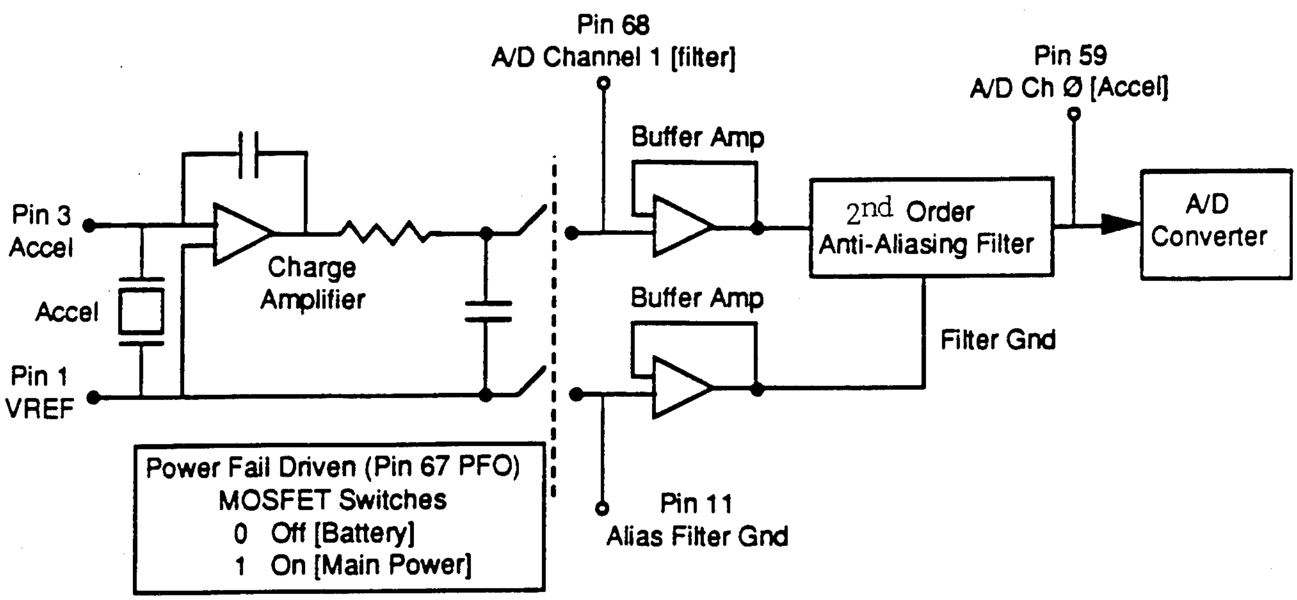


Figure 2-4. Vibration Sensor Circuitry

2.1.5 DC Voltage and Temperature

The DC voltage that powers the Micro-TSMD can be monitored or an external voltage source can be monitored. This option is user selectable. The input power voltage monitoring is done after the transient protection circuitry to ensure that the analog-to-digital (A/D) converter is protected from voltage spikes. The ambient temperature of the Micro-TSMD or of an external voltage sensor can be recorded. This option is user selectable. The temperature range of measurement is –55° to +125°C with a resolution of 1°C. Figure 2-5 shows the circuitry for monitoring the Micro-TSMD input voltage and the internal temperature sensor.

2.1.6 Transient Detection

The voltage transient detection circuitry is shown in Figure 2-6. It monitors transients on Pin 16 (Transient In). This pin may be tied to pin 17 (Power In) if the user chooses to monitor the source line voltage. The Micro-TSMD compares voltage transients to three separate thresholds. Two of the thresholds trigger on positive transients, and the remaining threshold triggers on negative transients. The levels are nominally 22, 11, and -11 volts respectively. The design allows the

circuit to survive transients with a magnitude of 100 V and can detect transients with a duration greater than 1 μs. The dark arrows in the block diagram indicate connection to the threshold references VT1, VT2, and VT3 available on the Micro-TSMD externally designated pins for threshold level setting.

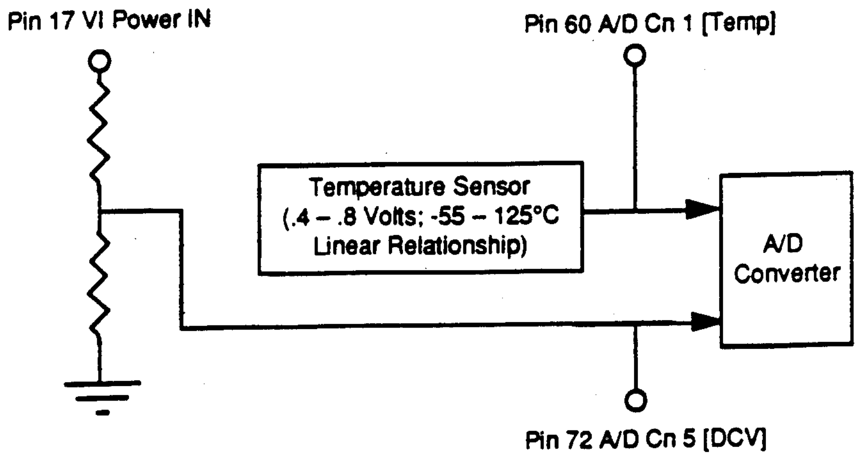


Figure 2-5. DC Voltage and Temperature Monitoring Circuitry

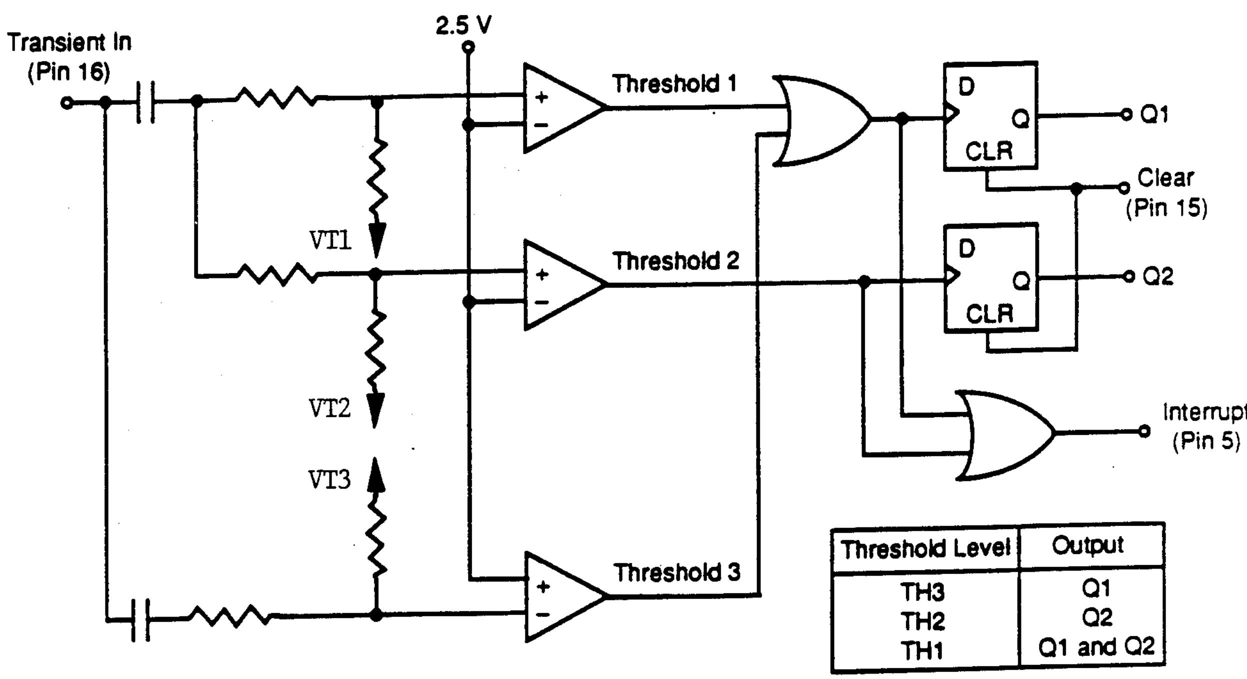


Figure 2-6. Transient Detection Circuitry

2.1.7 Digital Electronics

The block diagram of the digital architecture is shown in Figure 2-7. It is basically the same design as initially used in the Interim TSMD that was designed during the Micro-TSMD Design Definition Program. Added to the design is a 256 x 8 serial RAM. This addition was done by placing the memory chip on a small ceramic substrate and placing this smaller substrate on top of the main digital ceramic substrate. The small ceramic substrate provides the mounting and interconnect means to mount and connect the additional serial RAM.

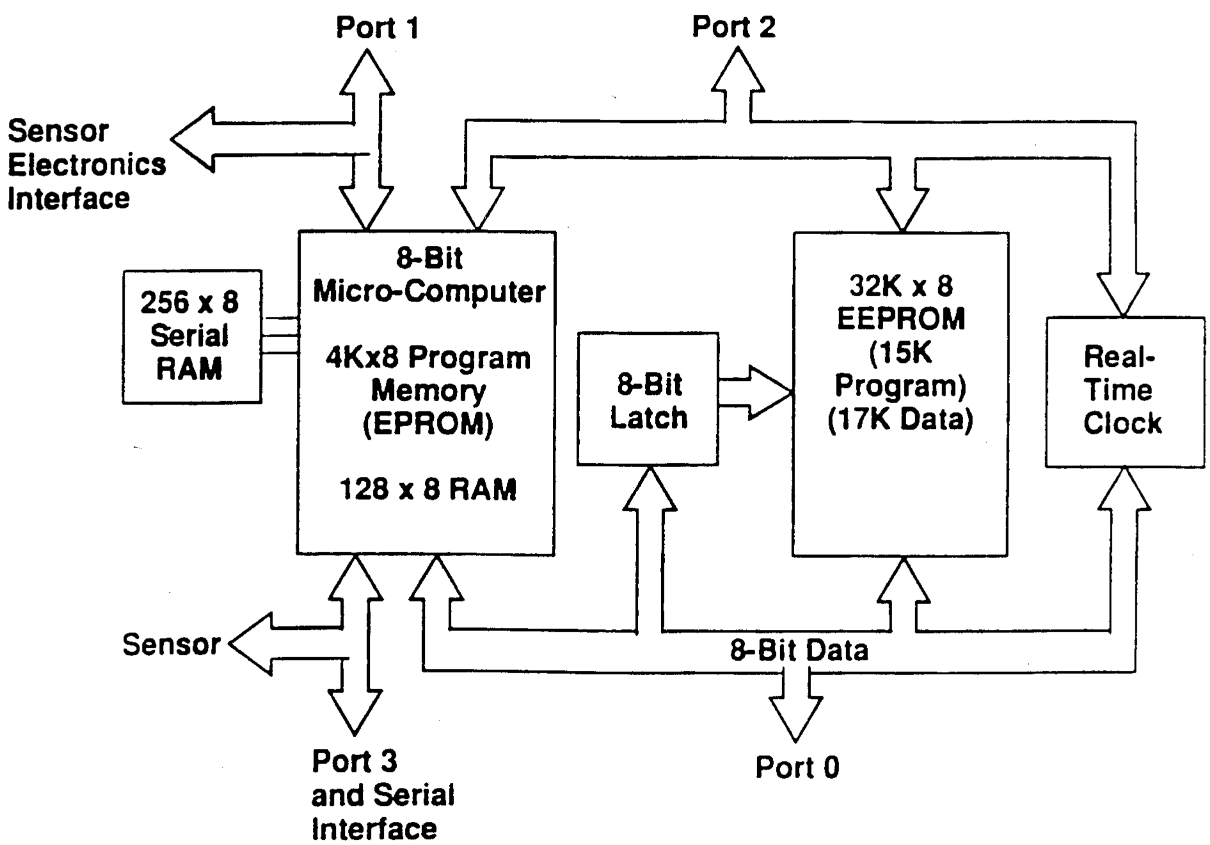


Figure 2-7. Micro-TSMD Digital Block Diagram

The processor for the Micro-TSMD is the Intel 87C51. This an 8-bit CMOS microcontroller that features 4K of internally Erasable Programmable Read-Only Memory (EPROM) for application-specific programming, 256 bytes of on chip RAM, two 16-bit timer/counters, 32 programmable I/O ports, and a Universal Asynchronous Receiver/Transmitter (UART) for serial communications.

Nonvolatile memory is needed to store stress data and any other application-specific programming that cannot be contained in the 87C51 EPROM. For this application an Electrically Erasable Programmable Read-Only Memory (EEPROM) is used The memory size is 32K x 8. The part is an Atmel 28C256. It is the largest single component in the Micro-TSMD. In the EEPROM 15K x 8 is used for program and 17K x 8 is used for data and text. There are reliability considerations when using EEPROMs. The number of times a memory location can be written to is finite. This is due in part to the Fowler-Nordheim tunneling current on the floating gate isolation dielectric. Typical endurance can range from 10,000 to 1,000,000 cycles per byte. The software has been designed to take this into account. The algorithms used for data storage do not require frequent writes. In addition, a test is performed to verify that each data write was successful. If it is not a new location is assigned in memory for that data.

The real-time clock for the TSMD is specifically designed for micropower time keeping to maximize the lifetime of the backup battery. The Intersil ICM7170 real-time clock chip made by Harris/Intersil is used in the Micro-TSMD. This device features a sneak-circuit protection circuit, which prevents the backup battery from powering the rest of the TSMD electronics during main power down periods. The ICM7170 keeps time to 0.01 sec. The oscillator frequency used for real-time keeping with the ICM7170 is 32.768 kHz.

The TSMD requires two oscillators to provide time references for the processor and the real-time clock. Both oscillators are temperature stable, have low power dissipation, and are small size. The real time clock oscillator operates at 32.768 kHz while the processor oscillator operates at 11.0592 MHz. The crystals selected are both made by Statek. The 32.768 kHz crystal is a new development in miniature crystal technology from Statek called the Model CX-4. This is a new "ultra-miniature" surface-mount quartz crystal. The package is only 0.205" x 0.080" x 0.045" and requires only half the surface area of the 11.0592-MHz miniature crystal being used for the processor.

2.2 Software Development and Data Reduction Techniques

Data reduction techniques are used to ensure that only non redundant information is saved. Several redundancy reduction techniques are used. The basic concept is to compare a predicted value with the actual value and then save or reject the information based upon whether it is within a defined tolerance. Prediction algorithms can be very simple or very complex. An example of one of the simplest algorithms is the zero-order predictor which compares the current sample with the previous sample and only saves the sample if it differs by more than a defined tolerance. To decide on the complexity of a data compression algorithm, several characteristics must be considered. These include the type of data, elapsed time, sampling rate, resolution, and the off-line data analysis to be performed.

2.2.1 Redundancy Reduction and Parameter Extraction

Since the environmental data collection techniques used in the Micro-TSMD are high speed and of high resolution, data management and data compression become a very important system issue. Constraints such as memory space and processor power limit the rate and amount of data that can be captured. Because of these limitations, several algorithms were studied before a data

management system was defined. Resolution, information loss, amount of data, redundancy, algorithm complexity, analysis of compressed data, and reliability were all issues that were considered in making the final determination. Complexity and amount of data are physical constraints of the system. The remaining criteria are determined by the final analysis of the data that is required. Almost all data contains some redundancy which can be removed by a variety of techniques. Some techniques cause information loss, while others allow the recreation of information without distortion. The main disadvantage of implementing data compression techniques is that the algorithms turn a synchronous data stream into an asynchronous data stream which increases the complexity of the system, solidifies the need for a data buffer, and requires time-stamping in order to recreate the continuous data stream with a real-time reference. Such data compression techniques however, are ideally suited for the Micro-TSMD application because a continuous data stream is not necessary and time stamping hardware is part of the system.

Data compression in the Micro-TSMD can be divided into the following categories:

- Redundancy reduction
- Parameter extraction

Redundancy reduction techniques are specifically designed to reduce the amount of data that needs to be stored. Most redundancy reduction techniques are prediction or interpolation algorithms that range from very low complexity to high complexity. The goal of these techniques is to eliminate data points that do not contain significant information. The efficiency of the compression technique depends on the amount of error that the algorithms introduce because of thresholding. But these techniques allow for reconstruction of the original wave form with a guaranteed accuracy, which is determined from the tolerance regions. The tolerance regions are software adjustable and user selectable.

Parameter extraction is usually an irreversible transformation. The amount of data and retrievable information is decreased, but important parameters or statistics are determined. Examples of parameter extraction are thresholding, histograms, frequency spectrum, peak recording, event recording, and statistical information.

2.2.2 Reduction Hardware Implementation

The Micro-TSMD collects data from the A/D converter and stores it in nonvolatile memory. The process of collection and storage is very involved. Data reduction tools are used to maximize the memory space. In describing the software algorithms, we will first discuss data collection techniques, then data reduction techniques, and finally data storage.

The digital section of the hybrid consists of an 8-bit microcontroller, a real-time clock, 256 bytes of serial RAM, and 32K bytes of nonvolatile EEPROM for data storage. The analog section of the Micro-TSMD consists of an A/D converter, a vibration sensor, a temperature sensor, a dc voltage sensor, a voltage transient detector, signal conditioning electronics, G threshold detectors, and voltage regulators. The hybrid is partitioned into functional blocks for reliability

and power conservation. (Individual blocks can be independently powered down). In addition to the internal sensors, external sensors can be interfaced to the Micro-TSMD. Although the Micro-TSMD uses digitally sampled sensors, analog threshold detectors can capture short duration transients such as a voltage spikes and vibration shocks. The following subsections describe how the software interprets the data collected by each of the sensors.

2.2.3 Voltage Data Reduction Implementation

The zero-order predictor used for voltage data filtering defines a tolerance level around the current sample value and only stores the next value if it is outside the tolerance. This predictor works best for signals that remain constant for long periods of time or for step functions. Because voltage remains constant, changes slowly, or has transients, the zero-order predictor is used to reduce redundancy. Figure 2-8 contains a plot of voltage vs. time and indicates which points are non redundant. A simplified algorithm for the zero-order predictor is:

1. Store sample and time stamp.

2. Define tolerance region from the stored value.

3. Continue sampling until a non redundant sample is obtained (sample outside of tolerance region).

4. Repeat.

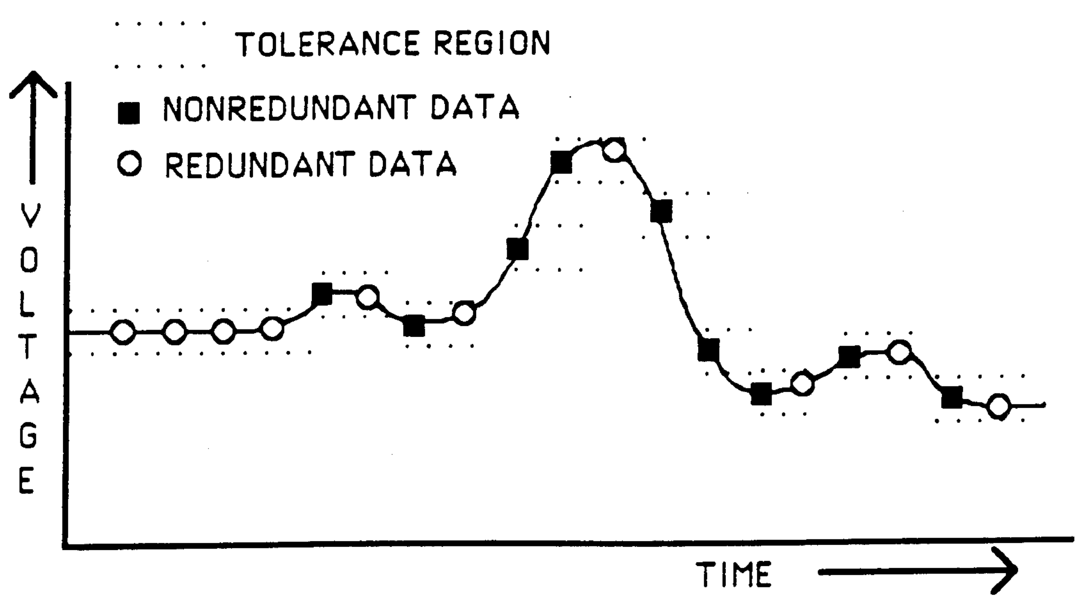


Figure 2-8. Zero-Order Predictor for Voltage

2.2.4 Voltage Transient Data Reduction Implementation

Voltage transients are read by two flip-flops. The flip-flops are driven by three comparators. The comparators are provided reference voltages from the same reference generator used to reference the A/D converter. Two of the comparators detect positive transients with each monitoring a different threshold level. The remaining comparator monitors negative transients. The analog circuitry is set up so that the outputs of the upper positive comparator and the negative comparator are connected to an OR gate. The gate drives the first flip-flop. The second flip-flop is driven directly by the lower positive comparator. The logic sequence is as follows:

- If a negative transient is encountered, the first flip-flop is set
- If a positive transient is detected that is higher than the first threshold yet lower than the second, the second flip-flop is set.
- If a positive transient is detected that is higher than the second positive threshold, then it must be higher than the first threshold also, and therefore both flip-flops are set.

The software that monitors the analog transient detector is polled in the main data acquisition loop. If a transient is detected it is recorded and the flip-flops are reset.

2.2.5 Temperature Data Reduction Implementation

Temperature in typical environments will remain constant or ramp slowly. To reduce redundancy in storing this type of signal a first-order predictor is used. The first-order predictor uses the last two sample values to define a slope and extrapolate a line. A tolerance region is then defined around this line and samples are taken but not saved until a sample is outside of the tolerance region. For a slope of zero, this algorithm reduces to the zero-order predictor. Figure 2-9 contains a plot of temperature vs. time and indicates which points are non redundant. A simplified algorithm for the first-order predictor is:

1. Store sample and time.
2. Define slope from next value.
3. Define tolerance region from slope and sample value.
4. Continue sampling until a non redundant sample is obtained.
5. Repeat.

Note: The algorthim actualy used is some what more complicated, as an examination of the data quickly shows.

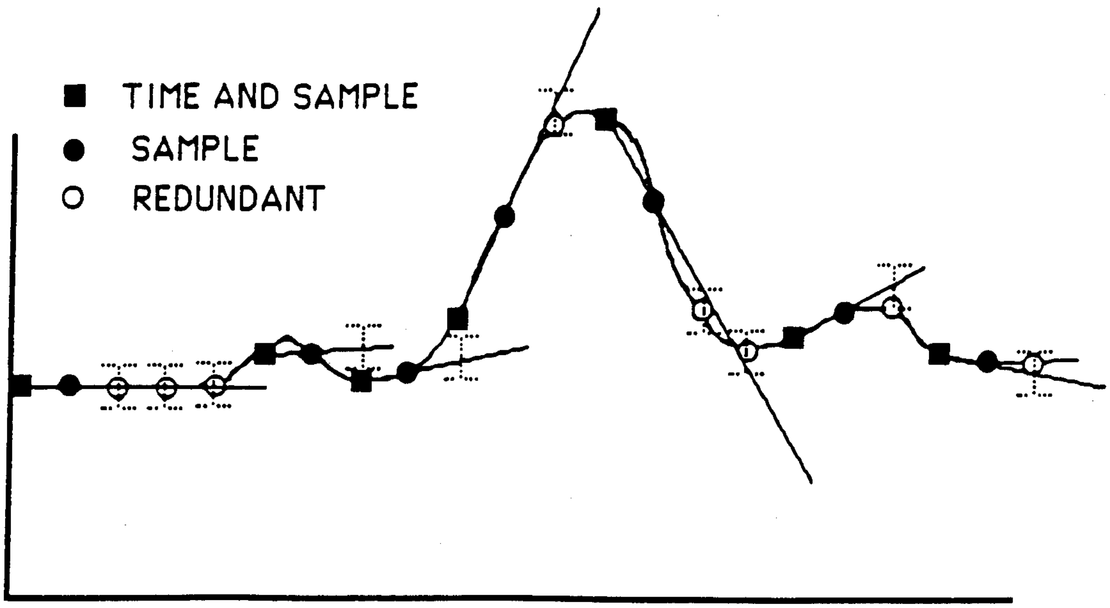


Figure 2-9. First-Order Predictor for Temperature

Figure 2-10 shows a sample data set of temperature data actually collected by the Micro-TSMD. The total time for this experiment was about 50 min.

The data accumulation options for this experiment were set at the default temperature sampling rate which is 1 sample every 4 sec. Without data compression, this temperature profile would have required 710 data points. With data compression only 27 points were stored, a mere 3.8% of 710. That corresponds to a 96.2% reduction.

00/00/00	00:00:00	020 DEG C
00/00/00	00:05:15	016 DEG C
00/00/00	00:06:10	011 DEG C
00/00/00	00:06:45	005 DEG C
00/00/00	00:07:15	-001 DEG C
00/00/00	00:08:05	-016 DEG C
00/00/00	00:08:30	-028 DEG C
00/00/00	00:10:20	-054 DEG C
00/00/00	00:10:40	-056 DEG C
00/00/00	00:15:25	-060 DEG C
00/00/00	00:19:45	-055 DEG C
00/00/00	00:20:00	-049 DEG C
00/00/00	00:26:10	094 DEG C
00/00/00	00:26:25	099 DEG C
00/00/00	00:28:30	120 DEG C
00/00/00	00:30:20	125 DEG C
00/00/00	00:35:40	119 DEG C
00/00/00	00:37:15	114 DEG C
00/00/00	00:39:15	108 DEG C

```
00/00/00   00:40:10   104 DEG C
00/00/00   00:40:45   099 DEG C
00/00/00   00:41:15   093 DEG C
00/00/00   00:43:20   065 DEG C
00/00/00   00:43:50   059 DEG C
00/00/00   00:45:35   044 DEG C
00/00/00   00:46:00   043 DEG C
00/00/00   00:47:20   039 DEG C

END OF DATA FILE(TYPE E TO CONTINUE)
```

Figure 2-10. Sample Set of Temperature Data

2.2.6 Vibration Data Reduction

Spectrum analysis is a technique that allows analysis of the data in the frequency domain rather than the time domain. The Fast Fourier Transform is used by the Micro-TSMD on the vibration data to obtain its spectrum as shown in Figure 2-11.

Frequencies with power below a user-defined threshold will not be recorded. The simplified algorithm for this procedure is:

1. Take a set of vibration samples.
2. Perform Fast Fourier Transform.
3. Record data in table.
4. Repeat.

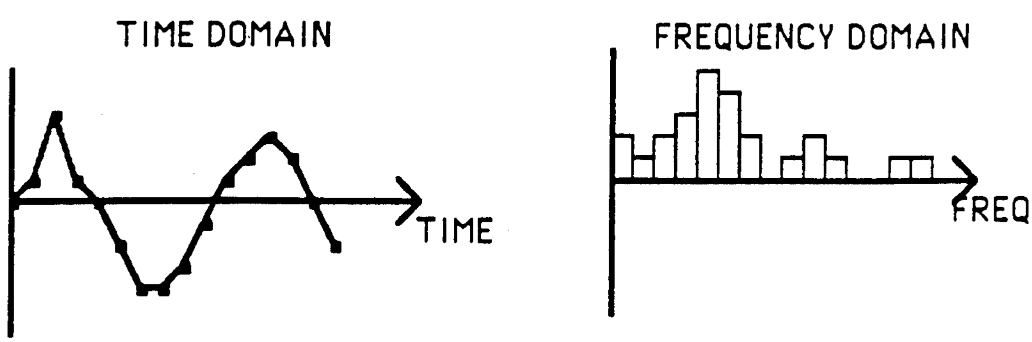


Figure 2-11. Spectrum Analysis

2.2.7 Shock Data Reduction

When the shock interrupt line toggles, the incoming shock data is sampled at the maximum sampling rate until the peak has been encountered. This increased data accuracy ensures an

accurate reading of the peak magnitude of an incoming shock. Under battery operation, 3 G or greater shock occurrences are collected in the shock counter. Upon power up, the software polls the counter to determine how many shocks were encountered.

2.2.8 Histogram Stress Data

Histograms are used to summarize the accumulative environmental stress. The vertical axis of the histogram represents the length of exposure to a stress, or the total number of times a stress occurred. In many cases, a user-selectable scale is used for the vertical axis so that a high amount of resolution is available for both a small and large amount of time or number of occurrences. The following stresses are recorded using histograms in the Micro-TSMD

- Total time "rate of change of temperature" was at a specific rate,
- Total time Micro-TSMD recorded a specific temperature,
- Total time Micro-TSMD recorded a specific voltage,
- Total number of voltage transients,
- Total time power of vibration was a specific value,
- Total number of shocks.

Section 3
Application Options

3.1 External Battery Operation

In regular operation the Micro-TSMD operates from a single 5 volt power supply. Internally this voltage is distributed to operate the various circuits including the real time clock and the vibration measurement and recording circuitry. Removing the 5 volt external supply silences all of the circuits of the device. The device however does have a provision to operate in the "sleep mode". This is a low power consumption mode and provides for monitoring and recording of vibrations/shocks and provides a time identification by keeping the real time clock operating.

In order to operate in the "sleep" mode an external 3 volt battery is required. This battery should be connected to pins 38 and 61 of the device.

3.2 External Accelerometer

The Micro-TSMD as delivered contains an internal accelerometer. The Micro-TSMD can be used with an external accelerometer substitute however, if desired. Figure 3-1 shows the device connections and switching available for selecting and connecting either the internal or the external accelerometer.

3.2.1 Procedure for Using an External Accelerometer

The internal anti-aliasing filter may be used with an external accelerometer. The anti-aliasing filter must be disconnected from the internal charge amplifier. This is accomplished by connecting Pin 67 (PFO) to ground (low). Grounding this pin disconnects both the charge amplifier and the reference signal ground from the anti-aliasing filter. The external accelerometer can then be connected to Pins 68 and 11 and the internal anti-aliasing filter can be utilized for filtering.

3.3 Using Extra A/D Channels

The Micro-TSMD has four unused A/D converter channels that may be used for a variety of analog and digital measurements. The system software as presently configured however does not process the inputs from these channels. These inputs are indicated as NC (no connection) in the device pinout definition. System software modifications would be required to accomplish this.

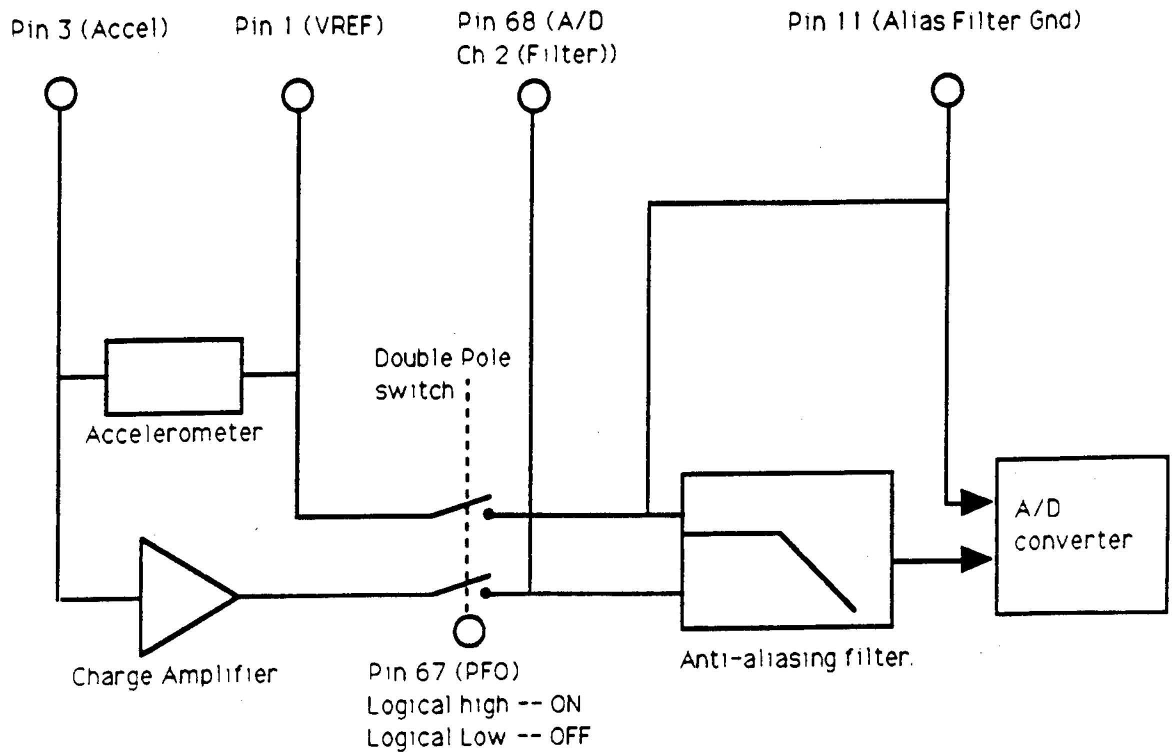


Figure 3-1. Anti-aliasing Filter and Accelerometer Switching Block Diagram
(See also Figure 2-4, Page 17)

Section 4
Input/Output Definitions

Figure 4-1 shows the footprint for the Micro-TSMD and its electrical connections. It is shown larger than actual size. Specific dimensions of the package and the printed circuit board layout to attach the package are given in Section 6. Tables 4-1A-C describe the pinout functions.

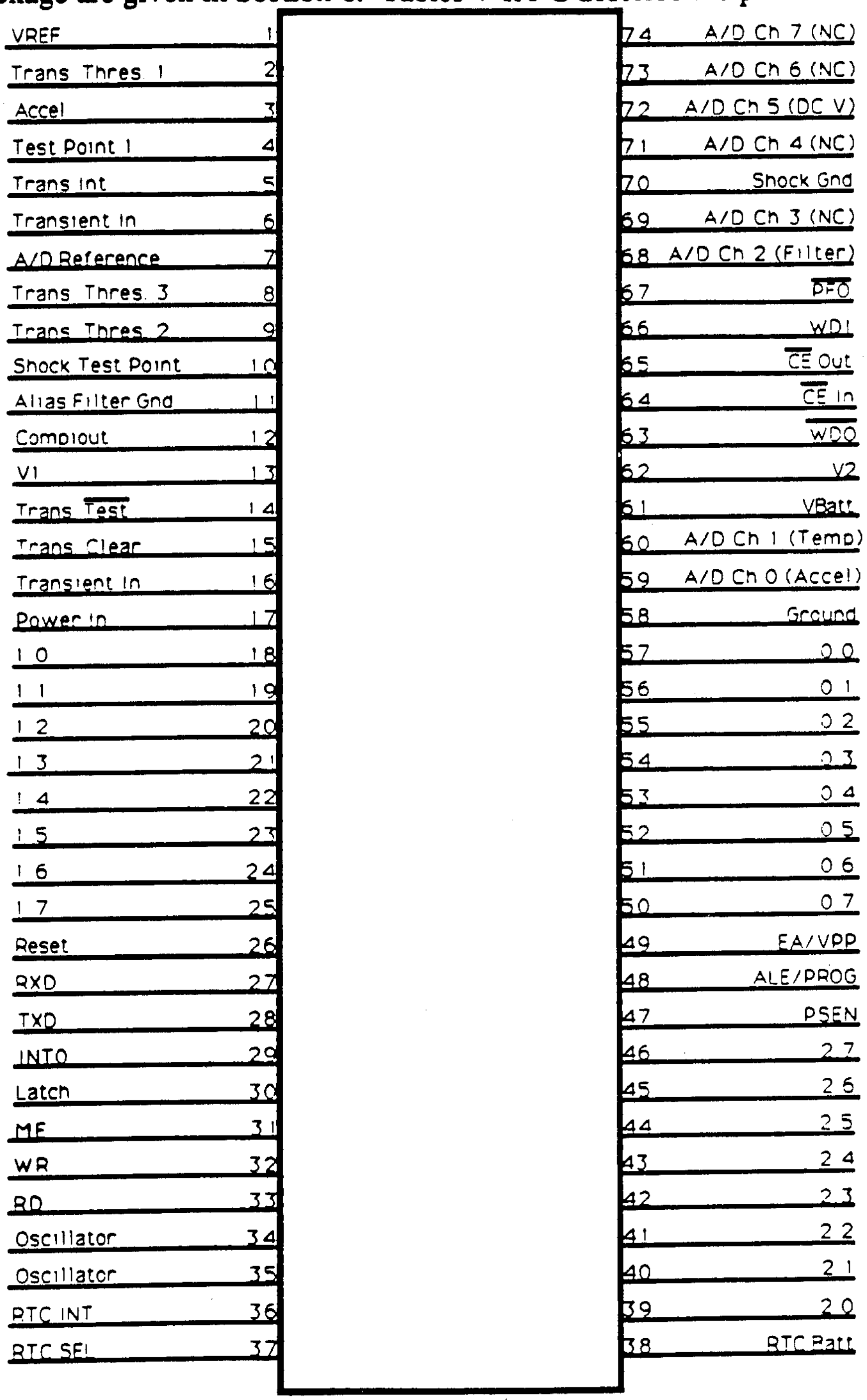


Figure 4-1. Micro-TSMD Footprint

Table 4-1A. Pinout Descriptions

Pin Num.	Pin Description
1	VREF Reference Voltage. Reference voltage for charge amplifier, shock thresholds, and anti-aliasing filter.
2	Trans. Thres. 1, Positive Transient Threshold Number 1.
3	Accel, Accelerometer. If the unit does not have an internal accelerometer, this pin is the input to the charge amplifier. If the unit is shipped with an internal accelerometer, this pin is the output of the accelerometer.
4	Test Point 1. Represents the transient signal after the dc filtering capacitor.
5	Trans. Int., Transient Interrupt Line. Informs microcontroller that a voltage transient has been detected.
6	Transient In, Transient Detector Input. May be tied to Micro-TSMD input power or other external voltage source to be monitored.
7	A/D Reference, Reference Voltage for A/D converter.
8	Trans. Thres. 3, Negative Transient Threshold.
9	Trans. Thres. 2, Positive Transient Threshold Number 2.
10	Shock Test Point. Output of the logical 'and' gate with the negative and positive shock thresholds as the inputs.
11	Alias Filter Gnd, Reference Ground for Anti-Aliasing Filter. Input is a buffered reference and may be tied externally to VREF when using the anti-aliasing filter with an external charge amplifier.
12	Comp out, Comparator Output. Output to an unused comparator. Inputs are not available through external pins.
13	V1. Micro-TSMD power after the transient surge protector.
14	Trans Test, Transient Latch Test Line.
15	Trans Clear, Transient Latch Clear.
16	Transient In, Transient Detector Input. Identical to pin 6.
17	Power In, Micro-TSMD Input Line. Main power input port; protected from voltage spikes.
18-25	1.0-1.7, Microcontroller Port 1.
26	Reset, Microcontroller reset line.
27	RXD, Serial Input Line.
28	TXD, Serial Output line.

Table 4-1B. Pinout Descriptions (Continued)

29	INT0, External Interrupt 0.
30	Latch
31	ME (Memory Enable)
32	WR, External Data Memory Write Strobe.
33	RD, External Data Memory Read Strobe.
34	Oscillator
35	Oscillator
36	RTC INT, Real Time Clock Interrupt.
37	RTC SEL, Real Time Clock Select.
38	RTC Batt, Real Time Clock Battery. Battery to maintain the Real Time Clock during power down.
39-46	2.0 - 2.7, Microcontroller Port 2. Used to address the EEPROM and Real Time Clock. Also used as data transfer to serial RAM.
47	PSEN, Program Store Enable.
48	ALE/PROG, Address Latch Enable.
49	EA/VPP External Access Enable.
50-57	0.7 – 0.0, Microcontroller Port 0. Used for addressing and data I/O to EEPROM. Also used to read the real time clock.
58	Ground.
59	A/D Ch 0 (Accel), Accelerometer Input to A/D.
60	A/D Ch 1 (Temp), Temperature Input to A/D.
61	Vbatt, External Battery Input. External power supply used to support the internal shock recorder during power down mode.
62	V2 Power to circuitry that may be operated under battery power. The line is internal selected to represent Pin 13 (V1) or Pin 61 (Vbatt), whichever is at a higher potential.
63	WDO, Watch Dog Output.
64	CE In, (Chip Enable)
65	CE Out,
66	WDI, (Watch Dog Timer)
67	PFO, Power Fail Output. Indicates logically whether V2 is being driven by V1 (logical one) or Vbatt (logical zero).
68	A/D Ch 2 (Filter), Pre-anti-aliasing filter Input to A/D. Input to anti-aliasing filter when external charge amplifier is being used.

Table 4-1C. Pin Descriptions (Concluded)

69	A/D Ch 3 (NC), Unused Input to A/D converter.
70	Shock Gnd, Ground reference for Shock Detector. Internally tied to Pin 58 (GND).
71	A/D Ch 4 (NC), Unused input to A/D converter.
72	A/D Ch 5 (DC V), dc Voltage Monitor A/D Input. Monitors DC Voltage level of Pin 13 (V1).
73	A/D Ch 6 (NC), Unused Input to A/D Converter.
74	A/D Ch 7 (NC), Unused Input to A/D Converter.

Table 4-2 shows the voltage levels expected at each of the pins of the Micro-TSMD under normal operating conditions.

Pin	Pin Title	Input/Output	Analog/Digital	Nominal Value (Volts)
1	VREF	Output	Analog	1.28
2	Trans Thres 1	Output	Analog	0.0
3	Accel.	Input/Output	Analog	1.27
4	Test Point 1	Output	Analog	0.0
5	Trans. Int.	Output	Digital	5.0
6	Transient In	Input	Analog	floating
7	A/D Reference	Output	Analog	2.50
8	Trans. Thres. 3	Output	Analog	5.0
9	Trans. Thres. 2	Output	Analog	0.0
10	Shock Test Point	Output	Digital	5.0
11	Alias Filter Gnd	Input	Analog	1.28
12	Compiout	Output	Unused	0.0
13	V1	Output	Analog	5.0
14	Trans. Test	Input/Output	Digital	5.0
15	Trans. Clear	Input/Output	Digital	5.0
16	Transient In	Input	Analog	Floating
17	Power In	Input	Analog	5.0
18–25	Port 1	Input/Output	Digital	Built In Test
26	Reset	Input	Digital	BIT
27	RXD	Input	Digital	BIT
28	TXD	Output	Digital	BIT
29	INT0	Input/Output	Digital	BIT
30	Latch		Digital	BIT
31	ME	Input/Output	Digital	BIT

32	WR	Input/Output	Digital	BIT
33	RD	Input/Output	Digital	BIT
34	Oscillator	Output	Digital	BIT
35	Oscillator	Output	Digital	BIT
36	RTC Int.	Output	Digital	BIT
37	RTC Sel.	Output	Digital	BIT
38	RTC Batt.	Input	Digital	BIT
39–46	Port 2	Input/Output	Digital	BIT
47	PSEN	Output	Digital	BIT
48	ALE/PROG	Input/Output	Digital	BIT
49	EA/VPP	Input/Output	Digital	BIT
50–57	Port 0	Input/Output	Digital	BIT
58	Ground	Input	Analog	0.0
59	A/D Ch. 0	Output	Analog	1.12
60	A/D Ch. 1	Output	Analog	.567
61	VBatt	Input	Analog	floating
62	V2	Output	Analog	4.96
63	WDO	Output	Digital	4.89
64	CE In	Input	Digital	4.90
65	CE Out	Output	Digital	4.96
66	WDI	Output	Digital	2.03
67	PFO	Input/Output	Digital	4.87
68	A/D Ch. 2	Output	Analog	1.26
69	A/D Ch. 3	Input	Analog	floating
70	Shock Gnd.	Input/Output	Analog	0.0
71	A/D Ch. 4	Input	Analog	floating
72	A/D Ch. 5	Output	Analog	1.27
73	A/D Ch. 6	Input	Analog	floating
74	A/D Ch. 7	Input	Analog	floating

Table 4-2 Micro-TSMD Pinout Voltages

```
                    MAINTENANCE

MICRO TIME STRESS MEASUREMENT DEVICE

    0     RETURN TO MAIN MENU
    1     VIEW
    2     EDIT
    3     INITIALIZE TEXT
    4     WRITE PROTECT

ENTER SELECTION >
```

Figure 5-3. MAINTENANCE LOG Menu

```
            INITIALIZING MEMORY

INITIALIZATION COMPLETE
ENTER NEW TEXT>

UTSMD NUMBER 32
SERVICE DATE: 6/22/91
TSMD NUMBER 1362-54A
```

Figure 5-4. Sample INITIALIZING TEXT Display

```
01  UTSMD NUMBER 32
02  SERVICE DATE: 6/22/91
03  MISSION NUMBER 1362-54A
```

Figure 5-5. Sample VIEW Display

5.4.3 Option 4—WRITE PROTECT

The WRITE PROTECT option is toggled on and off under option 4 of the MAINTENANCE LOG menu. Typing 4 at ENTER SELECTION on the MAINTENANCE LOG MENU displays the screen shown in Figure 5-6.

```
0 RETURN TO MAINTENANCE LOG MENU
1 WRITE PROTECT CURRENT LOG
2 UNDO WRITE PROTECT

ENTER SELECTION>
```

Figure 5-6. WRITE PROTECT Submenu

The message displayed after selecting option 1:

```
CURRENT LOG IS NOW WRITE PROTECTED
```

The message displayed after selecting option 2:

```
CURRENT LOG IS NOT WRITE PROTECTED
```

5.4.4 Option 2—EDIT

Editing existing text is accomplished by typing 2 at ENTER SELECTION on the MAINTENANCE LOG MENU. A series of options appears and the user can select from them. To exit the edit options, press ESC. Figure 5-7 shows a sequence of screens that illustrate adding and deleting text.

```
01  UTSMD NUMBER 32
02  SERVICE DATE: 6/22/91
03  MISSION NUMBER 1362-54A

ENTER D TO DELETE LAST LINE
ENTER A TO ADD NEW TEXT
OR ENTER LINE NUMBER (2 DIG) TO BE EDITED>
A
NEW DATA: FAILURE 7/23/98
```

Figure 5-7A. Adding New Text

```
01  UTSMD NUMBER 32
02  SERVICE DATE: 6/22/91
03  MISSION NUMBER 1362-54A
04  NEW DATA: FAILURE 7/23/98


ENTER D TO DELETE LAST LINE
ENTER A TO ADD NEW TEXT
OR ENTER LINE NUMBER (2 DIG) TO BE EDITED>
D
```

Figure 5-7B. Deleting Text

```
01  UTSMD NUMBER 32
02  SERVICE DATE: 6/22/91
03  MISSION NUMBER 1362-54A


ENTER D TO DELETE LAST LINE
ENTER A TO ADD NEW TEXT
OR ENTER LINE NUMBER (2 DIG) TO BE EDITED>
```

Figure 5-7C. Resulting Display

Figure 5-7A-C. EDIT Display Sequence

5.5 Using OPTIONS

Many of the ways the Micro-TSMD collects data are user adjustable. Sensor origin, filtering techniques, and data storage modes may be selected by the user before data collection begins. Typing 7 at ENTER SELECTION on the MAIN Menu lists the user definable options and gives their current setting as shown in Figure 5-8.

The options can be set to default values and the data tables may be reset by selecting option B, DEFAULT SETTINGS, as shown in Figure 5-9.

After memory initialization and default option setting, the options are listed as shown in Figure 5-10.

One can see that the DATA TABLE reset flag has been set during this initialization process. Each of the options is either toggled or entered by selecting the corresponding letter, as follows.

- Option A—Returns the user to the MAIN menu.

- Option B—Initializes memory and sets the data acquisition options to default values. Memory initialization destroys all previously collected accumulated and time-stamped data. Memory initialization does *not* affect the maintenance log. The default values for the data acquisition options are shown in Figure 5-10.

- Option C—Starts Data Acquisition; the following message appears:

  DATA ACQUISITION LOOP, E TO ESCAPE

- Option D—Determines whether or not the recorded temperature data should overwrite the oldest data should the data file length be exceeded.

- Option E—Determines whether or not the recorded shock data should overwrite the oldest data should the data file length be exceeded.

- Option F—Determines whether or not the recorded voltage data should overwrite the oldest data should the data file length be exceeded.

- Option G—Determines the sampling rate for the temperature data storage routine. The data sampled by the temperature storage routine is filtered through a first order predictor before actual storage occurs. Sample Rate: 1/sec to 1/99 hours.

- Option H—Sets the predictor tolerance range for the filtering predictor used by the temperature data storage routine.

- Option I—Sets the predictor tolerance range for the filtering predictor used by the voltage data storage routine.

```
DATA ACQUISITION

A   RETURN TO MAIN MENU
B   DEFAULT SETTINGS
C   START DATA ACQUISITION
D   TEMP ROLLOVER OPTION                  OFF
E   SHOCK ROLLOVER OPTION                 OFF
F   VOLT ROLLOVER OPTION                  OFF
G   TEMP SAMPLING PERIOD (HH:MM:SS))      00:00:04
H   TEMP TOLERANCE(DEG C)                 003
I   VOLT TOLERANCE                        020
J   VOLT DEADBAND MAX                     0.50
K   VOLT DEADBAND MIN                     0.50
L   SPECTRUM SCALE                        003
M   VOLT SENSOR                           INT
N   TEMP SENSOR                           INT
O   CLOCK BATTERY                         NO
P   SHOCK BATTERY                         NO
Q   TIME(MM/DD/YY  HH:MM:SS)              00/00/00  00:02:21
R   RESET DATA TABLES                     NOT RESET
S   FILE ALLOCATION               TEMP  4    VOLT   3    SHOCK  4

ENTER SELECTION>B
```

Figure 5-8. Initial DATA ACQUISITION Menu Shows Current Settings

```
INIT MEMORY

INIT MEMORY

INIT COMPLETE
```

Figure 5-9. DEFAULT SETTINGS Display

```
DATA ACQUISITION

A  RETURN TO MAIN MENU
B  DEFAULT SETTINGS
C  START DATA ACQUISITION
D  TEMP ROLLOVER OPTION                    OFF
E  SHOCK ROLLOVER OPTION                   OFF
F  VOLT ROLLOVER OPTION                    OFF
G  TEMP SAMPLING PERIOD (HH:MM:SS))        00:00:02
H  TEMP TOLERANCE(DEG C)                   003
I  VOLT TOLERANCE                          020
J  VOLT DEADBAND MAX                       0.50
K  VOLT DEADBAND MIN                       0.50
L  SPECTRUM SCALE                          003
M  VOLT SENSOR                             INT
N  TEMP SENSOR                             INT
O  CLOCK BATTERY                           NO
P  SHOCK BATTERY                           NO
Q  TIME(MM/DD/YY  HH:MM:SS)                00/00/00  00:02:21
R  RESET DATA TABLES                       RESET
S  FILE ALLOCATION                  TEMP  4   VOLT   3   SHOCK  4

ENTER SELECTION>B
```

Figure 5-10. DATA ACQUISITION Menu After DEFAULT SETTINGS

- Option J—The voltage deadband is a voltage range in which voltage data is never stored from. This range is usually set very close to the value of the expected voltage of the line being monitored. This option sets the upper limit of the voltage deadband.

- Option K—Sets the lower limit of the voltage deadband.

- Option L—Sets the vibration scale multiplier for the vibration data table.

- Option M—Selects which sensor voltage data is to be collected from.

- Option N—Selects which sensor temperature data is to be collected from.

- Option O—Informs the microcontroller as to the presence of an external real time clock battery.

- Option P—Informs the microcontroller as to the presence of an external shock counter battery.

- Option Q—Sets and displays the current date and time being kept by the Micro-TSMD.

- Option R—Resets the data tables and initializes memory for data collection.

- Option S—Sets how much memory is allocated for each type of stored data.

5.6 Using TIME-STAMPED DATA

Time-stamped data refers to data that is stored with a reference to a specific time and environmental data sample. Temperature data is one type of data that is stored with this time reference. This type of data can be collected and displayed by the Micro-TSMD. The time-stamped data display and collection options as shown in Figure 5-11 are displayed by typing 2 after ENTER SELECTION on the MAIN Menu.

Typing 1 at ENTER SELECTION on the TIME-STAMPED DATA menu will give the TIME-STAMPED DATA DISPLAY menu shown in Figure 5-12. The selections made in this menu display all of the currently stored data that refers to the selected sensor. Keep in mind that in all cases the data has been filtered through a predictor for data reduction purposes. For more information on the data collection and filtering process, refer to Section 2.

Typing 1 at ENTER SELECTION on the TIME-STAMPED DATA DISPLAY menu will display all of the current temperature data, like the example given in Figure 2-10. The figure shows actual data collected by the Micro-TSMD. The data table lists each time-stamped datum collected. Column one is the date, column two the time, and column three is the recorded value of temperature in degrees Celsius. The data is stored according to the options set by OPTIONS from the MAIN menu.

```
TIME-STAMPED DATA

THE Honeywell MICRO TIME STRESS MEASUREMENT DEVICE

    0     RETURN TO MAIN MENU
    1     DISPLAY
    2     COLLECTION

ENTER SELECTION>
```

Figure 5-11. TIME-STAMPED DATA Menu

```
TIME STAMPED DATA DISPLAY

THE Honeywell MICRO TIME STRESS MEASUREMENT DEVICE

    0     RETURN TO MAIN MENU
    1     TEMP
    2     VOLTAGE
    3     SHOCK
    4     VOLTAGE TRANSIENT
    5     HSF

ENTER SELECTION>
```

Figure 5-12. TIME-STAMPED DATA DISPLAY Menu

Typing 2 at ENTER SELECTION on the TIME-STAMPED DATA DISPLAY menu will display the Current Voltage Data, as shown in Figure 5-13. Column one is the date, column two the time, and column three is the voltage recorded in dc volts. The data is stored according to the options set by OPTIONS (from the MAIN menu).

Typing 3 at ENTER SELECTION on the TIME-STAMPED DATA DISPLAY menu will display the Current Shock Record, as shown in Figure 5-14. Column one is the date, column two the time, and column three is the magnitude of the shock in G. The data is stored according to the options set by OPTIONS from the MAIN menu.

Typing 4 at ENTER SELECTION on the TIME-STAMPED DATA DISPLAY menu will display the Current Voltage Transient Record, as shown in Figure 5-15. Column one is the date, column two the time, and column three names one of the three possible voltage transient levels: POS1, POS2, and NEG. The voltage level coincident with each of these levels is listed in Section 6. Voltage transients are measured from pin 16 or 6. These two pins are connected internally.

Typing 5 at ENTER SELECTION on the TIME-STAMPED DATA DISPLAY menu will display the Host Fault Indicator Record (HSF) as shown in Figure 5-16. Column one is the date, column two the time, and column three indicates the logical level of the signal. The host fault indicator operates off of channel 3 of the A/D converter. This channel corresponds to Micro-TSMD pin number 69.

```
00/00/00    00:00:00    1.22 V

END OF DATA FILE(TYPE E TO CONTINUE)
```

Figure 5-13. Current Voltage Data

```
00/00/00    00:00:36    022 G
00/00/00    00:00:36    037 G
00/00/00    00:00:36    041 G
00/00/00    00:00:36    016 G
00/00/00    00:00:36    018 G
00/00/00    00:00:36    030 G
00/00/00    00:00:36    019 G
00/00/00    00:00:48    025 G
00/00/00    00:01:20    008 G
00/00/00    00:01:26    033 G
00/00/00    00:01:26    014 G
00/00/00    00:01:35    026 G
00/00/00    00:01:36    034 G
00/00/00    00:01:36    021 G
00/00/00    00:01:36    008 G

END OF DATA FILE(TYPE E TO CONTINUE)
```

Figure 5-14. Current Shock Record

```
00/00/00    00:12:40    NEG
00/00/00    00:12:40    POS 1
00/00/00    00:12:41    NEG
00/00/00    00:12:42    POS 1
00/00/00    00:12:43    NEG
00/00/00    00:12:45    NEG
00/00/00    00:12:47    POS 1
00/00/00    00:12:48    NEG
00/00/00    00:12:56    NEG
00/00/00    00:12:57    POS 1
00/00/00    00:13:05    NEG
00/00/00    00:13:06    POS 1

END OF DATA FILE(TYPE E TO CONTINUE)
```

Figure 5-15. Current Voltage Transient Record

```
00/00/00    00:12:30    LOW
00/00/00    00:12:31    HIGH
00/00/00    00:12:34    LOW
00/00/00    00:12:34    HIGH
00/00/00    00:12:35    LOW
00/00/00    00:12:37    HIGH
00/00/00    00:12:38    LOW
00/00/00    00:12:57    HIGH
00/00/00    00:12:58    LOW
00/00/00    00:13:01    HIGH
00/00/00    00:13:02    LOW

END OF DATA FILE(TYPE E TO CONTINUE)
```

Figure 5-16. Host Fault Indicator Record

Typing 2 at ENTER SELECTION on the TIME-STAMPED DATA menu will give the TSD COLLECT menu shown in Figure 5-17. These are the user's time-stamped data collection options.

Each of the options collects data of that specific type. The data is collected according to the specifications set by OPTIONS from the MAIN menu.

```
TSD COLLECT


THE Honeywell MICRO TIME STRESS MEASUREMENT DEVICE

    0     RETURN TO MAIN MENU
    1     TEMP
    2     VOLTAGE
    3     HSF

ENTER SELECTION>
```

Figure 5-17. TIME-STAMPED DATA COLLECTION (TSD COLLECT) Menu

5.7 Using ACCUMULATIVE DATA

Accumulative data is data that is collected over time but is stored as a sums or extremes without a continuous time reference.

The accumulative data options are displayed by typing 3 after ENTER SELECTION on the MAIN Menu, which will display the ACCUMULATIVE DATA DISPLAY menu shown in Figure 5-18.

All of the options in this menu display the current data for the specific sensor.

Typing 1 at ENTER SELECTION on the ACCUMULATIVE DATA DISPLAY menu will display the Vibration Spectrum Display time table as shown in Figure 5-19. The table shows the total time (in minutes) that the measured vibration frequency was at each of eight discrete levels of magnitude. The SCALE # refers to the number entered in the OPTIONS menu. Figure 5-19 shows the corresponding magnitude levels of each bin when the SCALE # is set to the default value:

```
ACCUMULATIVE DATA DISPLAY


THE Honeywell MICRO TIME STRESS MEASUREMENT DEVICE

     0     RETURN TO MAIN MENU
     1     VIBRATION SPECTRUM
     2     VIBRATION POWER AND SHOCKS
     3     TEMP
     4     VOLTAGE AND ON/OFF CYCLES
     5     PEAK EVENTS
     6     TIME IN ACQUISITION LOOP
     7     SHOCKS

ENTER SELECTION>
```

Figure 5-18. ACCUMULATIVE DATA DISPLAY Menu

```
TIME IN MINS, VIBRATION LEVEL UNITS ARE X 10^-3  G^2/HZ
LEVEL>>  11-20 21-30 31-40 41-50 51-60 61-70 71-80 >81
 000 HZ  00000 00000 00000 00000 00000 00000 00000 00000
 100 HZ  00000 00000 00000 00000 00000 00000 00000 00000
 200 HZ  00000 00000 00000 00000 00000 00000 00000 00000
 300 HZ  00000 00000 00000 00000 00000 00000 00000 00000
 400 HZ  00000 00000 00000 00000 00000 00000 00000 00000
 500 HZ  00000 00000 00000 00000 00000 00000 00000 00000
 600 HZ  00000 00000 00000 00000 00000 00000 00000 00000
 700 HZ  00000 00000 00000 00000 00000 00000 00000 00000
 800 HZ  00000 00000 00000 00000 00000 00000 00000 00000
 900 HZ  00000 00000 00000 00000 00000 00000 00000 00000
1000 HZ  00000 00000 00000 00000 00000 00000 00000 00000
1100 HZ  00000 00000 00000 00000 00000 00000 00000 00000
1200 HZ  00000 00000 00000 00000 00000 00000 00000 00000
1300 HZ  00000 00000 00000 00000 00000 00000 00000 00000
1400 HZ  00000 00000 00000 00000 00000 00000 00000 00000
1500 HZ  00000 00000 00000 00000 00000 00000 00000 00000
1600 HZ  00000 00000 00000 00000 00000 00000 00000 00000
1700 HZ  00000 00000 00000 00000 00000 00000 00000 00000
1800 HZ  00000 00000 00000 00000 00000 00000 00000 00000
1900 HZ  00000 00000 00000 00000 00000 00000 00000 00000

TYPE ANY KEY TO CONTINUE
```

Figure 5-19. VIBRATION SPECTRUM Display

Typing 2 at ENTER SELECTION on the ACCUMULATIVE DATA DISPLAY menu will display the time at each of 14 discrete G RMS levels as shown in Figure 5-20. This table represents the entire spectrum and, hence, is not frequency dependent. Note that the time scale for each level is different. The device recording scale has been adjusted to maximize the accuracy of data collection.

Typing 3 at ENTER SELECTION on the ACCUMULATIVE DATA DISPLAY menu will display accumulated temperature data as shown in Figure 5-21. The first table summarizes the temperature ramps. A ramp has a time duration of one minute and a magnitude change of one of seven discrete levels. Each time a temperature ramp is encountered, it is fit into its respective ramp model and one is added to the table. Each of the seven discrete ramp models can be positive or negative, making a total of 14 different occurrence totals.

The second table displays the time (in minutes) that the temperature was at each of 36 discrete levels. The number "3" in row 2, column 3, indicates 3 minutes were spent in a temperature range of 0 °C to 5 °C.

Typing 4 at ENTER SELECTION on the ACCUMULATIVE DATA DISPLAY menu will display the ON/OFF cycle accumulated data as shown in Figure 5-22. First, the number of cycles is given. Second, a table showing the duration of the ON portion of the ON/OFF cycle is

printed. Third, the number of voltage transients at each of three discrete levels is displayed. This was added to this display routine to save space.

```
TIME AT G RMS LEVEL

00000   HRS AT 0.5 - 1.0 G RMS
00000   HRS AT 1.0 - 1.5 G RMS
00000   MINS AT 1.5 - 2.0 G RMS
00000   MINS AT 2.0 - 2.5 G RMS
00000   MINS AT 2.5 - 3.0 G RMS
00000   MINS AT 3.0 - 3.5 G RMS
00000   MINS AT 3.5 - 4.0 G RMS
00000   MINS AT 4.0 - 4.5 G RMS
00000   MINS AT 4.5 - 5.0 G RMS
00002   SECS AT 5.0 - 6.0 G RMS
00000   SECS AT 6.0 - 7.0 G RMS
00000   SECS AT 7.0 - 8.0 G RMS
00000   SECS AT 8.0 - 9.0 G RMS
00000   SECS AT 9.0 - 10.0 G RMS


TYPE ANY KEY TO CONTINUE
```

Figure 5-20. VIBRATION POWER AND SHOCKS Display

```
TEMP CHANGE IN 1 MIN

DEG C               RISE      FALL
 5-10               00000     00000
10-15               00000     00000
15-20               00000     00000
20-30               00000     00000
30-40               00000     00000
40-50               00000     00000
50-60               00000     00000



TOTAL TIME AT TEMP (MINUTES)
-55 TO 125 DEG C, BINS OF 5 DEG C, READ LEFT TO RIGHT
00000  00000 00000 00000 00000 00000 00000 00000 00000
00000  00000 00003 00000 00000 00000 00000 00001 00000
00000  00000 00000 00000 00000 00000 00000 00000 00000
00000  00000 00000 00000 00000 00000 00000 00000 00000

TYPE ANY KEY TO CONTINUE
```

Figure 5-21. TEMP Display

Typing 5 at ENTER SELECTION on the ACCUMULATIVE DATA DISPLAY menu will display the stored Peak Events as shown in Figure 5-23. Both an exact time of occurrence to the second and level are listed for each type of data.

Typing 6 at ENTER SELECTION on the ACCUMULATIVE DATA DISPLAY menu will first display the total Time in the Data Acquisition Loop Display. Second it shows the total time at each of 11 discrete voltage levels ranging from 4.0 to 6.0 V as shown in Figure 5-24. This voltage data is taken while the device is in the data acquisition loop and is intended to give the user a quick check to see if the data has been invalidated by an improper input voltage. Maximum working input voltage specification is given in Section 6.

Typing 7 at ENTER SELECTION on the ACCUMULATIVE DATA DISPLAY menu will display the current Shock Display as shown in Figure 5-25. Shocks are recorded in two ways: (1) in the main data acquisition and (2) during battery-powered shock counter operation. The first numbers in the data refer to the battery-powered shock counter. The table lists the number of shocks encountered at each of eight discrete magnitude bins while the device was in the main data acquisition loop. Shocks during last power down always shows a value. If the shock battery is not connected, this number will be random. The shocks-during-battery-power number is updated only when the shock battery option is selected.

```
ON/OFF CYCLES = 00001

<1 MIN:    001     1 MIN:    000
10 MIN:    000    30 MIN:    000
60 MIN:    000    90 MIN:    000
 2 HRS:    000     3 HRS:    000
 4 HRS:    000     5 HRS:    000
 6 HRS:    000     7 HRS:    000
 8 HRS:    000     9 HRS:    000
10 HRS:    000    11 HRS:    000
12 HRS:    000    13 HRS:    000
14 HRS:    000    15 HRS:    000
16 HRS:    000    17 HRS:    000
18 HRS:    000    19 HRS:    000
20 HRS:    000    21 HRS:    000
22 HRS:    000    23 HRS:    000
24 HRS:    000

VOLT TRANS
 NEG    POS 1    POS 2
00000   00000    00000

TYPE ANY KEY TO CONTINUE
```

Figure 5-22. VOLTAGE AND ON/OFF CYCLES Display

```
MIN TEMP(C): 00/00/00    00:00:03     017
MAX TEMP(C): 00/00/00    00:00:03     017
MAX SHOCK(G): 00/00/00    00:00:00    000
MIN VOLT(V): 00/00/00    00:00:06    1.22
MAX VOLT(V): 00/00/00    00:00:00    1.24


TYPE ANY KEY TO CONTINUE
```

Figure 5-23. PEAK EVENTS Display

```
TOTAL TIME IN ACQUISITION LOOP:
00000 DAYS     00 HOURS    00 MINUTES

TOTAL TIME AT VOLTAGES +/- 0.1V

4.0 VOLTS:  00000 DAYS  00 HOURS 00 MINUTES
4.2 VOLTS:  00000 DAYS  00 HOURS 00 MINUTES
4.4 VOLTS:  00000 DAYS  00 HOURS 00 MINUTES
4.6 VOLTS:  00000 DAYS  00 HOURS 00 MINUTES
4.8 VOLTS:  00000 DAYS  00 HOURS 00 MINUTES
5.0 VOLTS:  00000 DAYS  00 HOURS 01 MINUTES
5.2 VOLTS:  00000 DAYS  00 HOURS 00 MINUTES
5.4 VOLTS:  00000 DAYS  00 HOURS 00 MINUTES
5.6 VOLTS:  00000 DAYS  00 HOURS 00 MINUTES
5.8 VOLTS:  00000 DAYS  00 HOURS 00 MINUTES
6.0 VOLTS:  00000 DAYS  00 HOURS 00 MINUTES
OUT OF RANGE:  00000 DAYS  00 HOURS  00 MINUTES

TYPE ANY KEY TO CONTINUE
```

Figure 5-24. TIME IN ACQUISITION LOOP Display

```
SHOCKS DURING LAST POWER-DOWN =  128

SHOCKS DURING BATTERY POWER =  00000

SHOCK MAGNITUDE DURING MISSION (G)
 3-4    5-6    7-9    10-13  14-17  19-21  22-25   >26
00000  00000  00000  00000  00000  00000  00000  00000

TYPE ANY KEY TO CONTINUE
```

Figure 5-25. SHOCKS Display

5.8 Using BUILT IN TEST

Typing 4 at ENTER SELECTION on the MAIN Menu will display the BUILT IN TEST Menu as shown in Figure 5-26.

Selecting option 1 performs the built-in test. The results of the test are printed on the screen in Figure 5-27. The operator is then returned to the BUILT IN TEST MENU.

```
            BUILT IN TEST MENU

The Honeywell MICRO TIME STRESS MEASUREMENT DEVICE

    0     RETURN TO MAIN MENU
    1     PERFORM BUILT IN TEST
    2     PERFORM EEPROM WEAROUT TEST

ENTER SELECTION >
```

Figure 5-26. BUILT IN TEST Menu

```
EEPROM TEST:
TEST PASSED

CLOCK TEST:
TEST PASSED

RAM TEST:
TEST PASSED

SRA TEST:
TEST PASSED

A TO D TEST:
POWER SUPPLY WITHIN RANGE
TEMPERATURE WITHIN RANGE
VIBRATION WITHIN RANGE
SHOCK WITHIN RANGE
```

Figure 5-27. PERFORM BUILT IN TEST Display

Selecting option 2 performs the EEPROM wear out test. Since the maximum write and read time of the EEPROM is 10 ms, the test takes approximately 15 minutes to fully complete. The wear out test partitions the EEPROM into 128 sections labeled as "pages" and prints the test results for each page as soon as that page's test is complete. The test may be halted at any time by typing E ([shift][e]). An example of the EEPROM wear out test is given in Figure 5-28.

After the test is complete or halted, the operator is returned to the BUILT IN TEST MENU. Typing 0 at ENTER SELECTION returns you to the MAIN Menu.

```
THERE ARE 000 ERRORS FOR PAGE 001
THERE ARE 000 ERRORS FOR PAGE 002
THERE ARE 000 ERRORS FOR PAGE 003
THERE ARE 000 ERRORS FOR PAGE 004
THERE ARE 000 ERRORS FOR PAGE 005
.
.
.
THERE ARE 000 ERRORS FOR PAGE 125
THERE ARE 000 ERRORS FOR PAGE 126
THERE ARE 000 ERRORS FOR PAGE 127
THERE ARE 000 ERRORS FOR PAGE 128
```

Figure 5-28. PERFORM EEPROM WEAROUT TEST Display

5.9 Using DEBRIEFING

Data collected by the Micro-TSMD may be transferred to a host system using the DEBRIEF mode. Typing 5 for DEBRIEF at ENTER SELECTION in the MAIN menu sets the Micro-TSMD into data dump mode. This mode dumps all data and cannot be interrupted. The data is listed in Figure 5-29 exactly as it will occur after a key is pressed.

```
PREPARE HOST TO RECEIVE DATA

TYPE ANY KEY TO CONTINUE
```

Figure 5-29. DEBRIEF Display

```
TEMPERATURE

00/00/00    00:00:15    017 DEG C
00/00/00    00:00:47    014 DEG C
00/00/00    00:00:59    011 DEG C
00/00/00    00:01:23    009 DEG C
00/00/00    00:02:11    078 DEG C
00/00/00    00:02:19    079 DEG C
00/00/00    00:03:03    076 DEG C
00/00/00    00:05:35    073 DEG C
END OF DATA FILE(TYPE E TO CONTINUE)
```

Figure 5-29. DEBRIEF Display (Continued)

```
VOLTAGE

00/00/00    00:00:00   1.22 V
END OF DATA FILE(TYPE E TO CONTINUE)
```

Figure 5-29. DEBRIEF Display (Continued)

```
VOLTAGE TRANSIENT

00/00/00    00:12:40   NEG
00/00/00    00:12:40   POS 1
00/00/00    00:12:41   NEG
00/00/00    00:12:42   POS 1
00/00/00    00:12:43   NEG
00/00/00    00:12:45   NEG
00/00/00    00:12:47   POS 1
00/00/00    00:12:48   NEG
00/00/00    00:12:56   NEG
00/00/00    00:12:57   POS 1
00/00/00    00:13:05   NEG
00/00/00    00:13:06   POS 1
END OF DATA FILE(TYPE E TO CONTINUE)
```

Figure 5-29. DEBRIEF Display (Continued)

```
SHOCK

00/00/00    00:00:36   022 G
00/00/00    00:00:36   037 G
00/00/00    00:00:36   041 G
00/00/00    00:00:36   016 G
00/00/00    00:00:36   018 G
00/00/00    00:00:36   030 G
00/00/00    00:00:36   019 G
00/00/00    00:00:48   025 G
00/00/00    00:01:20   008 G
00/00/00    00:01:26   033 G
00/00/00    00:01:26   014 G
00/00/00    00:01:35   026 G
00/00/00    00:01:36   034 G
00/00/00    00:01:36   021 G
00/00/00    00:01:36   008 G
END OF DATA FILE(TYPE E TO CONTINUE)
```

Figure 5-29 DEBRIEF Display (Continued)

```
TIME-STAMPED HSF

00/00/00    00:12:30   LOW
00/00/00    00:12:31   HIGH
00/00/00    00:12:34   LOW
00/00/00    00:12:34   HIGH
00/00/00    00:12:35   LOW
00/00/00    00:12:37   HIGH
00/00/00    00:12:38   LOW
00/00/00    00:12:57   HIGH
00/00/00    00:12:58   LOW
00/00/00    00:13:01   HIGH
00/00/00    00:13:02   LOW
END OF DATA FILE(TYPE E TO CONTINUE)
```

Figure 5-29. DEBRIEF Display (Continued)

```
TIME IN MINS, VIBRATION LEVEL UNITS ARE X 10^-3  G^2/HZ
LEVEL>>  11-20 21-30 31-40 41-50 51-60 61-70 71-80 >81
 000 HZ  00000 00000 00000 00000 00000 00000 00000 00000
 100 HZ  00000 00000 00000 00000 00000 00000 00000 00000
 200 HZ  00000 00000 00000 00000 00000 00000 00000 00000
 300 HZ  00000 00000 00000 00000 00000 00000 00000 00000
 400 HZ  00000 00000 00000 00000 00000 00000 00000 00000
 500 HZ  00000 00000 00000 00000 00000 00000 00000 00000
 600 HZ  00000 00000 00000 00000 00000 00000 00000 00000
 700 HZ  00000 00000 00000 00000 00000 00000 00000 00000
 800 HZ  00000 00000 00000 00000 00000 00000 00000 00000
 900 HZ  00000 00000 00000 00000 00000 00000 00000 00000
1000 HZ  00000 00000 00000 00000 00000 00000 00000 00000
1100 HZ  00000 00000 00000 00000 00000 00000 00000 00000
1200 HZ  00000 00000 00000 00000 00000 00000 00000 00000
1300 HZ  00000 00000 00000 00000 00000 00000 00000 00000
1400 HZ  00000 00000 00000 00000 00000 00000 00000 00000
1500 HZ  00000 00000 00000 00000 00000 00000 00000 00000
1600 HZ  00000 00000 00000 00000 00000 00000 00000 00000
1700 HZ  00000 00000 00000 00000 00000 00000 00000 00000
1800 HZ  00000 00000 00000 00000 00000 00000 00000 00000
1900 HZ  00000 00000 00000 00000 00000 00000 00000 00000
```

Figure 5-29. DEBRIEF Display (Continued)

```
TIME AT G RMS LEVEL

00000   HRS AT 0.5 - 1.0 G RMS
00000   HRS AT 1.0 - 1.5 G RMS
00000   MINS AT 1.5 - 2.0 G RMS
00000   MINS AT 2.0 - 2.5 G RMS
00000   MINS AT 2.5 - 3.0 G RMS
00000   MINS AT 3.0 - 3.5 G RMS
00000   MINS AT 3.5 - 4.0 G RMS
00000   MINS AT 4.0 - 4.5 G RMS
00000   MINS AT 4.5 - 5.0 G RMS
00002   SECS AT 5.0 - 6.0 G RMS
00000   SECS AT 6.0 - 7.0 G RMS
00000   SECS AT 7.0 - 8.0 G RMS
00000   SECS AT 8.0 - 9.0 G RMS
```

Figure 5-29. DEBRIEF Display (Continued)

```
TEMP CHANGE IN 1 MIN

DEG C                  RISE     FALL
 5-10                  00000    00000
10-15                  00000    00000
15-20                  00000    00000
20-30                  00000    00000
30-40                  00000    00000
40-50                  00000    00000
50-60                  00000    00000

TOTAL TIME AT TEMP (MINUTES)
-55 TO 125 DEG C, BINS OF 5 DEG C, READ LEFT TO RIGHT
00000  00000  00000  00000  00000  00000  00000  00000  00000
00000  00000  00000  00000  00000  00000  00000  00001  00000
00000  00000  00000  00000  00000  00000  00000  00000  00000
00000  00000  00000  00000  00000  00000  00000  00000  00000
```

Figure 5-29. DEBRIEF Display (Continued)

```
ON/OFF CYCLES = 00001

<1 MIN:     001      1 MIN:     000
10 MIN:     000     30 MIN:     000
60 MIN:     000     90 MIN:     000
 2 HRS:     000      3 HRS:     000
 4 HRS:     000      5 HRS:     000
 6 HRS:     000      7 HRS:     000
 8 HRS:     000      9 HRS:     000
10 HRS:     000     11 HRS:     000
12 HRS:     000     13 HRS:     000
14 HRS:     000     15 HRS:     000
16 HRS:     000     17 HRS:     000
18 HRS:     000     19 HRS:     000
20 HRS:     000     21 HRS:     000
22 HRS:     000     23 HRS:     000
24 HRS:     000
```

Figure 5-29. DEBRIEF Display (Continued)

```
VOLT TRANS
 NEG    POS 1    POS 2
00000   00000   00000

MIN TEMP(C): 00/00/00   00:00:03   017
MAX TEMP(C): 00/00/00   00:00:03   017
MAX SHOCK(G): 00/00/00   00:00:00   000
MIN VOLT (V) 00/00/00   00:00:06   1.22
MAX VOLT (V) 00/00/00   00:00:00   1.24

SHOCKS DURING LAST POWER-DOWN =  128

SHOCKS DURING BATTERY POWER =  00000

SHOCK MAGNITUDE DURING MISSION (G)
 3-4    5-6    7-9    10-13  14-17  19-2   22-25  >26
00000  00000  00000  00000  00000  00000  00000  00000

TOTAL TIME IN ACQUISITION LOOP:
00000 DAYS    00 HOURS    00 MINUTES

TOTAL TIME AT VOLTAGES +/- 0.1V

4.0 VOLTS:     00000 DAYS    00 HOURS    00 MINUTES
4.2 VOLTS:     00000 DAYS    00 HOURS    00 MINUTES
4.4 VOLTS:     00000 DAYS    00 HOURS    00 MINUTES
4.6 VOLTS:     00000 DAYS    00 HOURS    00 MINUTES
4.8 VOLTS:     00000 DAYS    00 HOURS    00 MINUTES
5.0 VOLTS:     00000 DAYS    00 HOURS    01 MINUTES
5.2 VOLTS:     00000 DAYS    00 HOURS    00 MINUTES
5.4 VOLTS:     00000 DAYS    00 HOURS    00 MINUTES
5.6 VOLTS:     00000 DAYS    00 HOURS    00 MINUTES
5.8 VOLTS:     00000 DAYS    00 HOURS    00 MINUTES
6.0 VOLTS:     00000 DAYS    00 HOURS    00 MINUTES
OUT OF RANGE:  00000 DAYS    00 HOURS    00 MINUTES

TYPE ANY KEY TO CONTINUE
```

Figure 5-29. DEBRIEF Display (Concluded)

5.10 Using UTILITIES

The Micro-TSMD software includes utilities. These utilities are intended to give the user direct access to data as it is being generated. The UTILITY menu as shown in Figure 5-30 is displayed by typing 6 at ENTER SELECTION on the MAIN Menu.

Typing 1 at ENTER SELECTION on the UTILITY menu will display the current date and time as shown in Figure 5-31.

Typing 2 at ENTER SELECTION on the UTILITY menu accesses the EEPROM. The user is asked for a starting address from which the data read should begin as shown in

Figure 5-32. This option is a diagnostic tool that displays the EEPROM in hexadecimal. It is not used during normal operation.

Typing 3 at ENTER SELECTION on the UTILITY menu provides direct access to the sensors via the SENSORS menu as shown in figure 5-33.

```
UTILITY

THE Honeywell MICRO TIME STRESS MEASUREMENT DEVICE

    0    RETURN TO MAIN MENU
    1    READ TIME
    2    EEPROM
    3    SENSORS
    4    SERIAL RAM
    5    A/D

ENTER SELECTION>
```

Figure 5-30. UTILITY Menu

```
E TO EXIT, S TO STOP/START
THE TIME IS (MM/DD/YY HH:MM:SS)>00/00/00  00:02:45
```

Figure 5-31. READ TIME Display

```
ENTER STARTING ADDRESS (0000-7FFF)>0000
00 00 00 00 00 00 00 00 00 00 00 00 03 52 FF 22
0A 00 20 02 38 36 C2 D1 12 06 2A 75 F0 0A A4 C8
12 06 2A 28 22 F4 C0 E0 E5 3E B4 AA 03 02 00 33
12 02 C0 D0 E0 12 02 AA 75 17 00 A2 AF 50 05 C2
AF 75 17 FF 12 03 76 60 EF 12 02 94 E5 3E B4 AA
03 02 00 57 12 03 1B E0 C0 E0 E5 17 B4 FF 02 D2
AF D0 E0 22 75 81 25 75 82 29 74 37 12 04 D5 90
07 F0 12 04 05 75 B0 FF 75 A0 DF 75 90 FF 74 ED
12 07 4A 12 07 80 90 4E FF 74 00 F0 75 82 50 74
00 12 04 D5 12 06 F7 90 4E DE E0 B4 FF 10 78 40
74 30 F6 08 E8 B4 60 F8 12 05 44 12 05 89 00 75
98 50 75 89 21 75 8D FD 75 87 00 D2 8E D2 AF 90
4E DA E0 60 03 02 08 08 12 49 30 02 1A E0 74 20
12 06 84 D5 0E FA 22 90 4E D0 11 26 F5 65 90 4E
D1 11 26 F5 66 90 4E CE 11 26 F5 24 90 4E CF 11
26 F5 83 85 24 82 7F 01 12 43 89 A3 11 26 F5 0E
E5 82 B5 65 08 E5 83 B5 66 03 02 01 12 E5 0E B4
FF E9 85 82 24 85 83 22 75 82 27 E5 24 12 04 D5
75 82 28 E5 22 12 04 D5 90 4E D8 11 26 F5 65 90
4E D9 11 26 F5 66 90 4E D6 11 26 F5 24 90 4E D7
11 26 F5 83 85 24 82 7F 01 12 43 89 A3 11 26 F5
0E AC 82 AD 83 12 13 93 12 11 E6 12 06 3F E5 82
B5 65 08 E5 83 B5 66 03 02 01 70 E5 0E B4 FF DC
E TO EXIT OR TYPE ANY OTHER KEY FOR MORE DATA > X
85 82 24 85 83 22 75 82 58 E5 24 12 04 D5 75 82
59 E5 22 12 04 D5 90 4E D4 11 26 F5 65 90 4E D5
11 26 F5 66 90 4E D2 11 26 F5 24 90 4E D3 11 26
F5 83 85 24 82 7F 01 12 43 89 A3 11 26 F5 0E AC
82 AD 83 12 13 93 12 11 E6 12 06 3F E5 82 B5 65
08 E5 83 B5 66 03 02 01 CE E5 0E B4 FF DC 85 82
24 85 83 22 75 82 51 E5 24 12 04 D5 75 82 52 E5
22 12 04 D5 22 C0 E0 E5 3E B4 AA 03 02 01 F2 12
02 C0 D0 E0 C0 E0 12 02 AA 75 17 00 A2 AF 50 05
C2 AF 75 17 FF 12 07 85 40 44 F9 12 03 76 60 FB
E9 F0 12 02 66 30 00 36 C2 00 74 02 2E F5 F0 74
AA C3 95 F0 20 E7 27 AB 83 AF 82 90 4F 00 E5 82
2E F5 82 EB F0 12 02 66 A3 EF F0 12 02 66 0E 0E
90 4E FF EE F0 12 02 66 8B 83 8F 82 80 BD 12 02
94 E5 3E B4 AA 03 02 02 5C 12 03 1B E5 17 B4 FF
02 D2 AF D0 E0 22 7D 06 12 07 80 DD FB 75 23 00
FC E0 12 02 79 B5 04 F9 22 C3 C2 00 F5 F0 ED 24
01 FD E5 23 34 00 F5 23 C3 94 07 40 04 D2 00 EC
22 E5 F0 22 E5 70 85 71 F0 A8 72 A9 73 AA 74 AB
75 AC 76 AD 77 AE 78 AF 79 22 F5 70 85 F0 71 88
72 89 73 8A 74 8B 75 8C 76 8D 77 8E 78 8F 79 22
85 82 21 C0 E0 75 82 39 E5 70 12 04 D5 75 82 3A
E5 71 12 04 D5 75 82 3B E5 72 12 04 D5 75 82 3C
E TO EXIT OR TYPE ANY OTHER KEY FOR MORE DATA > E
TYPE ANY KEY TO CONTINUE
```

Figure 5-32. EEPROM Display

```
SENSORS

THE Honeywell MICRO TIME STRESS MEASUREMENT DEVICE

    0     RETURN TO MAIN MENU
    1     SHOCK
    2     VIBRATION
    3     TEMP
    4     VOLT
    5     FAULT
    6     VOLT TRANSIENT

ENTER SELECTION>
```

Figure 5-33. SENSORS Menu

Typing 1 at ENTER SELECTION on the SENSORS menu accesses the Shock Sensor as shown in Figure 5-34. The routine will wait for a shock to occur or an E to be typed.

Typing 2 at ENTER SELECTION on the SENSORS menu displays the Vibration Sensor Display as shown in Figure 5-35.

Typing 3 at ENTER SELECTION on the SENSORS menu displays the Current Temperature Display as shown in Figure 5-36.

Typing 4 at ENTER SELECTION on the SENSORS menu displays the Current Voltage Display as shown in Figure 5-37.

Typing 5 at ENTER SELECTION on the SENSORS menu displays the current logical level of the Host Fault indicator as shown in Figure 5-38.

Typing 6 at ENTER SELECTION on the SENSORS menu accesses the voltage transient sensor as shown in figure 5-39.

```
WAITING FOR SHOCK(E TO EXIT)-MAGNITUDE=
TYPE ANY KEY TO CONTINUE
```

Figure 5-34. SHOCK Sensor Display

```
0Hz   |
100   |
200   |
300   |
400   |
500   |
600   |
700   |
800   |
900   |**************************
1000  |************************************************
1100  |***************************
1200  |
1300  |
1400  |
1500  |
1600  |
1700  |
1800  |
1900  |
2000  |
```

Figure 5-35. VIBRATION Sensor Display

```
             TEMP (DEG C) 018
TYPE ANY KEY TO CONTINUE
```

Figure 5-36. TEMP Sensor Display

```
VOLT IS 1.22 V
TYPE ANY KEY TO CONTINUE
```

Figure 5-37. VOLT Sensor Display

```
             HSF IS LOW

TYPE ANY KEY TO CONTINUE
```

Figure 5-38. FAULT Sensor Display

```
WAITING FOR VOLTAGE TRANSIENT(E TO EXIT)-MAGNITUDE=
TYPE ANY KEY TO CONTINUE
```

Figure 5-39. VOLT TRANSIENT Sensor Display

Typing 4 at ENTER SELECTION on the UTILITY menu gives the SERIAL RAM menu as shown in Figure 5-40. The serial RAM utility is a diagnostic tool that allows the user to read and write to the serial RAM. These routines are not used during normal operation.

Typing 1 at ENTER SELECTION on the SERIAL RAM menu reads the serial RAM as shown in Figure 5-41.

Typing 2 at ENTER SELECTION on the SERIAL RAM menu allows the user to write to any specific serial ram address. Figure 5-42 shows the user writing to location 00 the value FF.

To view the change, enter 1 again in the SERIAL RAM utility menu as shown in Figure 5-43.

```
SERIAL RAM

THE Honeywell MICRO TIME STRESS MEASUREMENT DEVICE

    0     RETURN TO MAIN MENU
    1     READ
    2     WRITE

ENTER SELECTION>
```

Figure 5-40. SERIAL RAM Menu

```
 000 084 000 000 000 000 000 000 000 000 000 000 000 000 000 000
 000 000 000 000 000 247 255 246 255 077 255 255 255 254 255 245
 255 253 255 247 255 251 255 007 080 050 061 031 255 000 255 223
 255 249 255 251 255 000 255 191 255 000 000 000 000 000 000 000
 000 000 000 002 000 000 000 024 000 010 000 064 000 198 000 014
 000 007 096 064 000 066 000 000 000 112 000 193 000 000 000 015
 000 204 000 001 000 148 000 004 000 012 000 048 000 001 000 049
 000 066 000 033 000 000 000 144 000 001 000 004 000 000 000 200
 255 247 255 253 255 247 255 191 255 227 255 125 255 247 255 235
 255 119 255 252 255 254 255 251 255 235 255 182 255 245 255 159
 255 159 255 249 255 191 255 247 255 237 255 149 255 221 255 186
 255 247 255 110 255 143 255 063 255 239 255 173 255 223 255 174
 128 034 000 168 000 068 000 136 000 162 000 024 000 232 000 038
 000 009 000 000 000 008 000 144 000 186 000 202 000 130 000 162
 000 056 000 170 000 194 000 170 000 130 000 032 000 010 000 008
 000 102 000 172 000 130 000 138 000 000 000 027 000 203 000 251

TYPE ANY KEY TO CONTINUE
```

Figure 5-41. READ Serial RAM Display

```
ENTER SERIAL RAM ADDRESS(00-FF)>00
ENTER # (00-FF)>FF
TYPE ANY KEY TO CONTINUE
```

Figure 5-42. WRITE Serial RAM Display

```
SERIAL RAM

THE Honeywell MICRO TIME STRESS MEASUREMENT DEVICE

    0     RETURN TO MAIN MENU
    1     READ
    2     WRITE

ENTER SELECTION> 1


 255 084 000 000 000 000 000 000 000 000 000 000 000 000 000 000
 000 000 000 000 000 247 255 246 255 077 255 255 255 254 255 245
 255 253 255 247 255 251 255 007 080 050 061 031 255 000 255 223
 255 249 255 251 255 000 255 191 255 000 000 000 000 000 000 000
 000 000 000 002 000 000 000 024 000 010 000 064 000 198 000 014
 000 007 096 064 000 066 000 000 000 112 000 193 000 000 000 015
 000 204 000 001 000 148 000 004 000 012 000 048 000 001 000 049
 000 066 000 033 000 000 000 144 000 001 000 004 000 000 000 200
 255 247 255 253 255 247 255 191 255 227 255 125 255 247 255 235
 255 119 255 252 255 254 255 251 255 235 255 182 255 245 255 159
 255 159 255 249 255 191 255 247 255 237 255 149 255 221 255 186
 255 247 255 110 255 143 255 063 255 239 255 173 255 223 255 174
 128 034 000 168 000 068 000 136 000 162 000 024 000 232 000 038
 000 009 000 000 000 008 000 144 000 186 000 202 000 130 000 162
 000 056 000 170 000 194 000 170 000 130 000 032 000 010 000 008
 000 102 000 172 000 130 000 138 000 000 000 027 000 203 000 251


TYPE ANY KEY TO CONTINUE
```

Figure 5-43. Updated READ Serial RAM Display

Typing 5 at ENTER SELECTION in the UTILITY menu prints out the intended channel sensor title followed by a current (continuously updated) channel reading as shown in Figure 5-44. The channel readings are to an accuracy of 10 bits (0 to 1024 decimal):

```
            CH. DESCRIPTION

0     INT/EXT VIB
1     INT TEMP
2     INT/EXT SHOCK
3     EXT FAULT
4     EXT VOLTAGE
5     TSMD Vcc
6     TSMD GND
7     EXT TEMP

CH READING(E TO EXIT)

  0     1     2     3     4     5     6     7
0200  0232  0056  1024  0000  0500  0000  1024

TYPE ANY KEY TO CONTINUE
```

Figure 5-44. A/D Display

5-11 MEMORY MAP

The Micro-TSMD memory can be found in three places in the system. First, there is 4K of memory on the 87C51 microcomputer chip which is used for program control. Another 32K of memory is available on the EEPROM which provides the nonvolatile means of recording and storing data and finally another small serial RAM (Random Access Memory) is used for scratchpad storage for operating dynamic memory. An overview of the major mapping locations in the various memories is shown in Figure 5-45.

```
SERIAL RAM

THE Honeywell MICRO TIME STRESS MEASUREMENT DEVICE

    0     RETURN TO MAIN MENU
    1     READ
    2     WRITE

ENTER SELECTION> 1


 255 084 000 000 000 000 000 000 000 000 000 000 000 000 000 000
 000 000 000 000 000 247 255 246 255 077 255 255 255 254 255 245
 255 253 255 247 255 251 255 007 080 050 061 031 255 000 255 223
 255 249 255 251 255 000 255 191 255 000 000 000 000 000 000 000
 000 000 000 002 000 000 000 024 000 010 000 064 000 198 000 014
 000 007 096 064 000 066 000 000 000 112 000 193 000 000 000 015
 000 204 000 001 000 148 000 004 000 012 000 048 000 001 000 049
 000 066 000 033 000 000 000 144 000 001 000 004 000 000 000 200
 255 247 255 253 255 247 255 191 255 227 255 125 255 247 255 235
 255 119 255 252 255 254 255 251 255 235 255 182 255 245 255 159
 255 159 255 249 255 191 255 247 255 237 255 149 255 221 255 186
 255 247 255 110 255 143 255 063 255 239 255 173 255 223 255 174
 128 034 000 168 000 068 000 136 000 162 000 024 000 232 000 038
 000 009 000 000 000 008 000 144 000 186 000 202 000 130 000 162
 000 056 000 170 000 194 000 170 000 130 000 032 000 010 000 008
 000 102 000 172 000 130 000 138 000 000 000 027 000 203 000 251


TYPE ANY KEY TO CONTINUE
```

Figure 5-43. Updated READ Serial RAM Display

Typing 5 at ENTER SELECTION in the UTILITY menu prints out the intended channel sensor title followed by a current (continuously updated) channel reading as shown in Figure 5-44. The channel readings are to an accuracy of 10 bits (0 to 1024 decimal):

```
              CH. DESCRIPTION

0      INT/EXT VIB
1      INT TEMP
2      INT/EXT SHOCK
3      EXT FAULT
4      EXT VOLTAGE
5      TSMD Vcc
6      TSMD GND
7      EXT TEMP

CH READING(E TO EXIT)

  0     1     2     3     4     5     6     7
0200  0232  0056  1024  0000  0500  0000  1024

TYPE ANY KEY TO CONTINUE
```

Figure 5-44. A/D Display

5-11 MEMORY MAP

The Micro-TSMD memory can be found in three places in the system. First, there is 4K of memory on the 87C51 microcomputer chip which is used for program control. Another 32K of memory is available on the EEPROM which provides the nonvolatile means of recording and storing data and finally another small serial RAM (Random Access Memory) is used for scratchpad storage for operating dynamic memory. An overview of the major mapping locations in the various memories is shown in Figure 5-45.

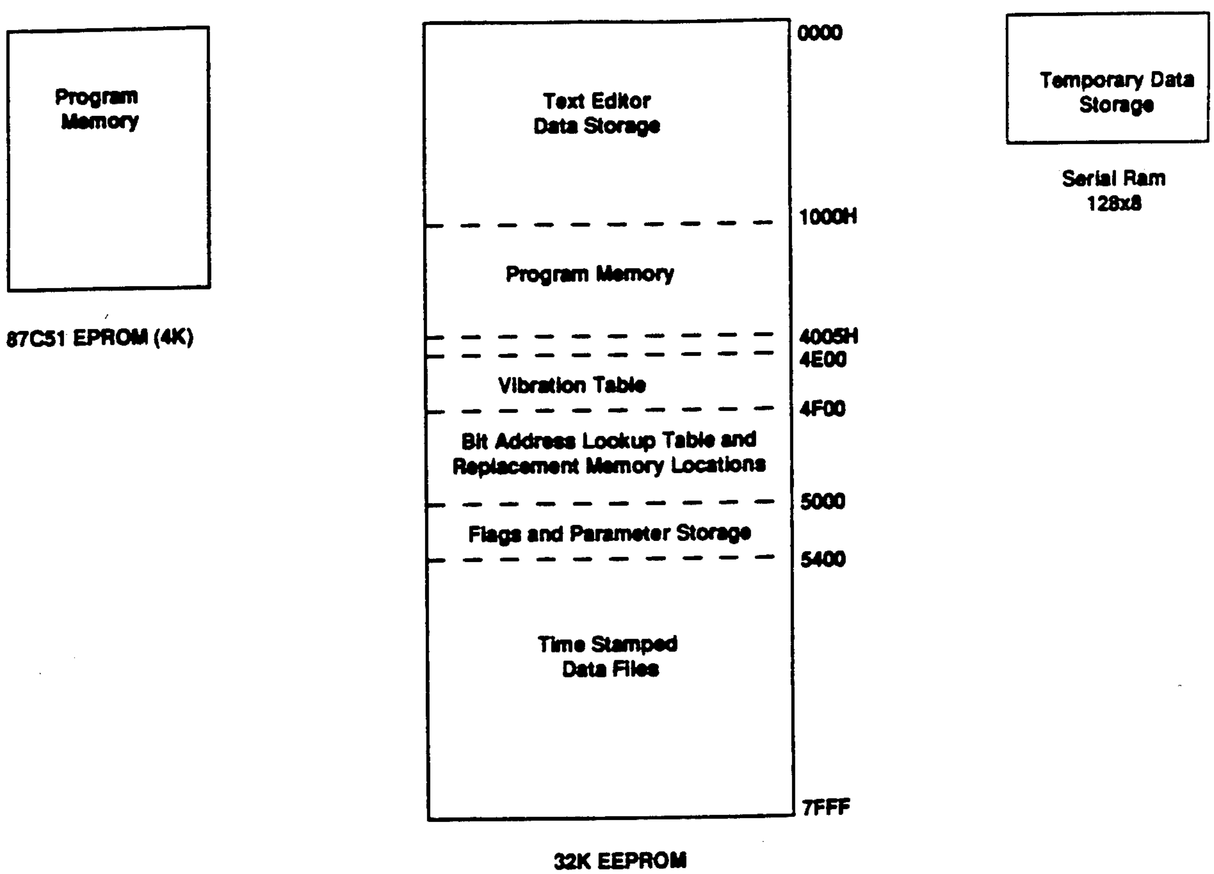


Figure 5-45 MEMORY MAP

Section 6
TSMD System Specifications

6.1 Sensor Circuits

6.1.1 Vibration Monitoring

- 64-point Fast Fourier Transform
- Outputs into 32 frequency bins with 20 usable bins and 12 bins are discarded due to over sampling and transition band of the low pass filter
- Frequency range: 20 to 2000 Hz
- Frequency bin resolution: 100 Hz
- Magnitude: 0.00 G2 /Hz to 0.45 G2 /Hz

6.1.2 Shock Counter

- Interrupt driven
- Sampling rate: 8 kHz
- Range: 3 to 25 G
- Positive threshold
- Negative threshold
- Resolution: 0.1 G

6.1.3 DC Voltage Measurement

- Sampling rate: constant
- Range: 0V- 10V
- Resolution: 0.04 V

6.1.4 Voltage Transient Detector

- Positive upper threshold: 40 V
- Positive lower threshold: 17 V
- Negative threshold: –17 V
- Minimum duration: 1 μs
- Maximum voltage: 100 V

6.1.5 Temperature Monitoring

- Sampling rate: user defined
- Range: –55°C to 125°C
- Resolution: 1°C

6.2 Electrical Limits

The Micro-TSMD Power line (Pin 17) is protected from external voltage spikes of a magnitude less than 100 V and a duration less than 10 ms.

6.3 Mechanical Limits

The Micro-TSMD has been tested at the following mechanical limits:

- Constant acceleration (Y-axis* only): 1500G
- Temperature: –55° C to 125° C

6.4 Power Consumption

- Active operation: 30 mW
- Battery operation: 135 µW

Detailed package dimensions are shown in Figure 6-1.

Figure 6-2 shows the package dimensions and the Printed Circuit Board Pad Mounting Requirements.

* Y-axis is perpendicular to the plane of the chip.

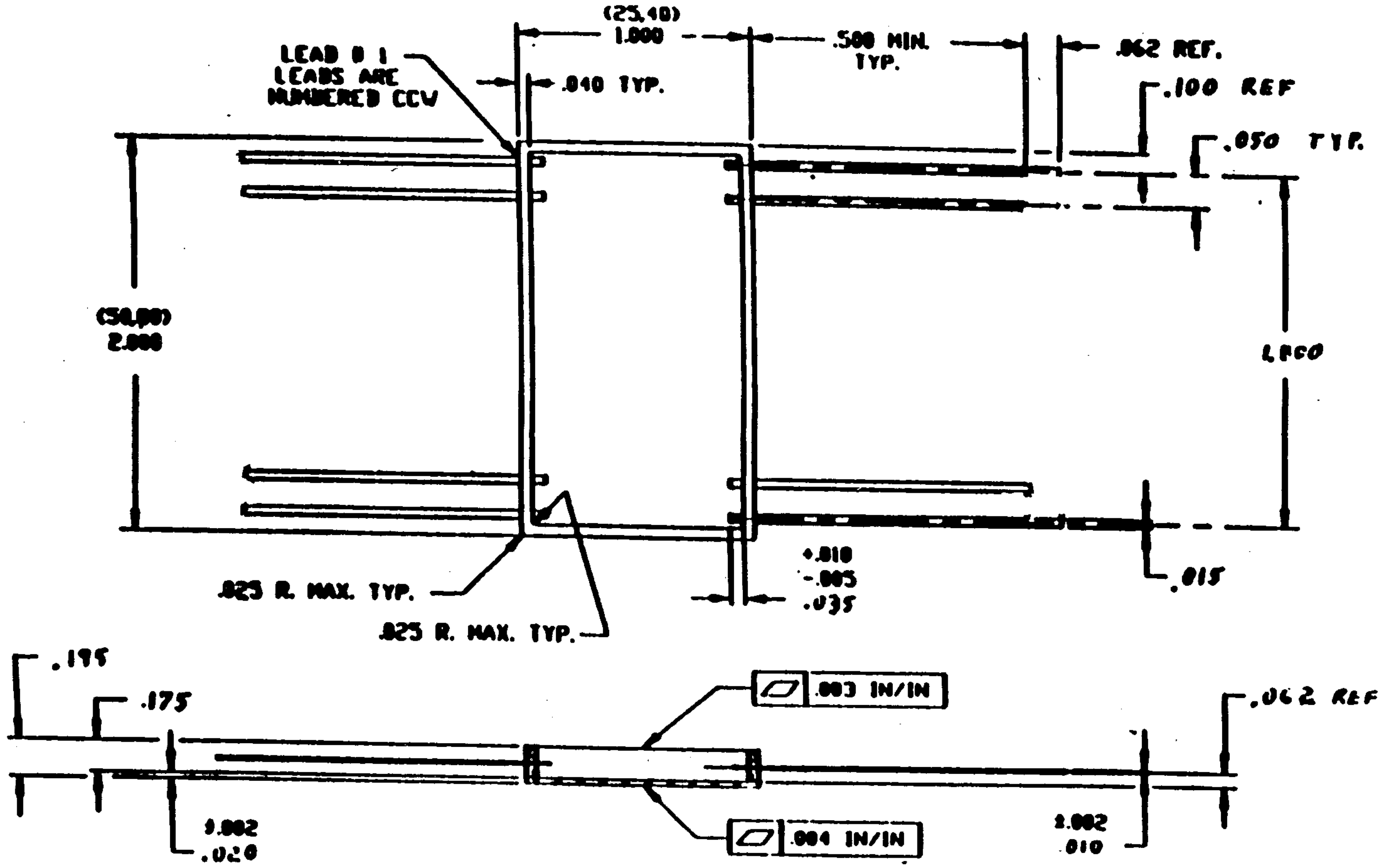


Figure 6-1 Micro TSMD-74 Pin Butterfly Lead Package

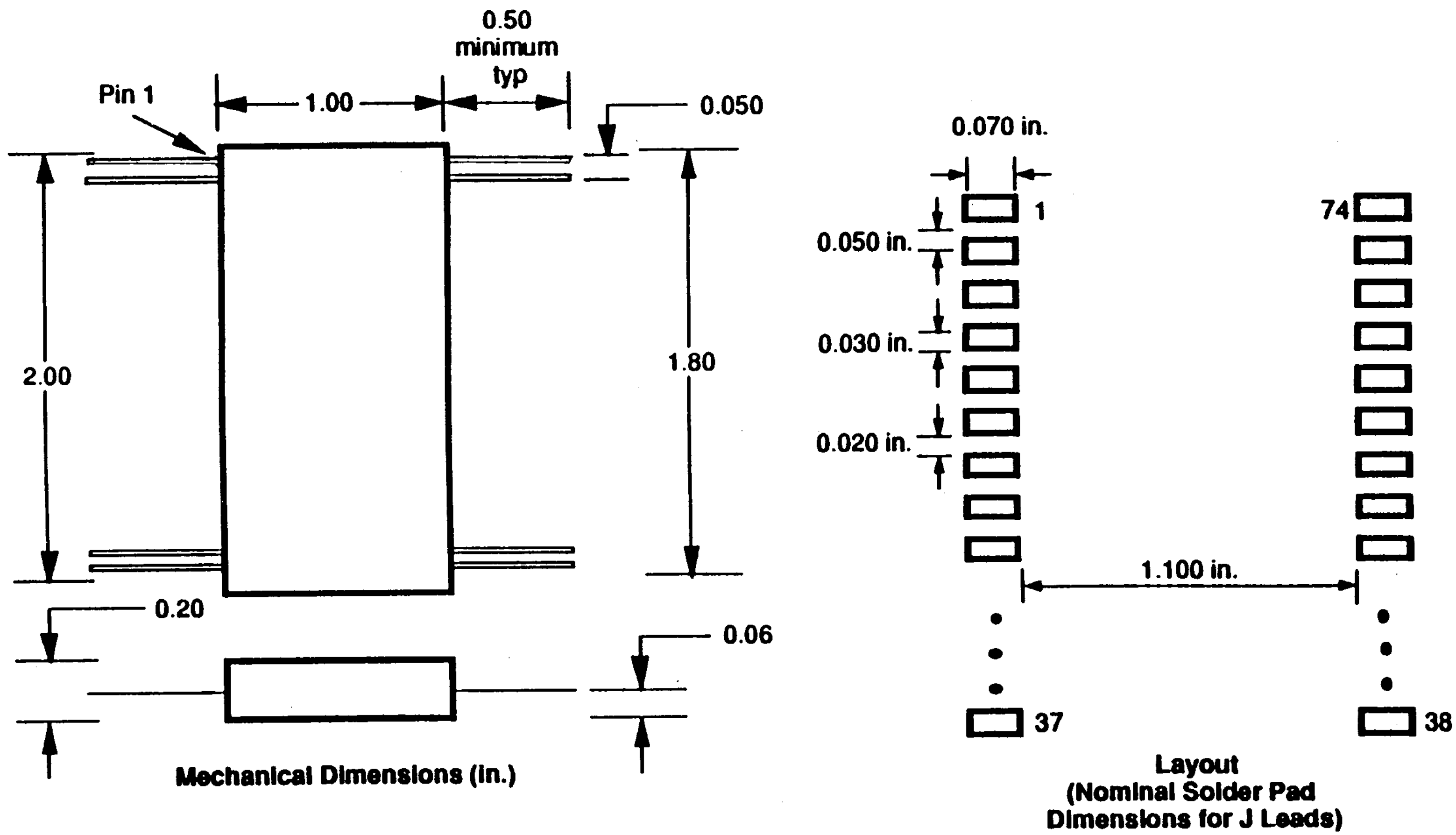


Figure 6-2 Package Dimensions and Printed Circuit Board Mounting Pad Layout

Section 7
Conclusions

This program demonstrated the feasibility of manufacturing a hybrid device which can be mounted on a circuit board and perform the full range of functions desired of a TSMD. The device can:

- record textual information which could become a permanent record of the logistic history of a circuit board (or LRU)
- display the vibration spectra
- record cumulative time of vibration at each frequency and amplitude level
- record temperature as a function of time
- record maxima of temperature, shock, and voltage
- record power quality

The Micro TSMD has a spare input channel and a host system fault indicator. Full production capability was not demonstrated.

At the start of the Micro-TSMD Development Program the Statement of Work called for the design of five additional Micro-TSMDs beyond the first twenty. The first twenty are referred to as the Preproduction Prototype Micro-TSMDs. The last five were referred to as the Production Prototype Micro-TSMDs. The difference between the two was that the Production Prototype Micro-TSMD was to have a multi-drop serial bus instead of the RS-232 serial bus as used in the Preproduction Prototype. In 1990 the decision was made by Rome Laboratory to make the interface to the Production Prototype Micro-TSMD a parallel data bus instead of a serial one in order to be better able to meet Warner Robins Air Logistic Center requirements. This was a significant change to the existing design that evolved from the interim TSMD program. Various options were presented by Honeywell to Rome Lab to add this feature to the Prepoduction Prototype. Rome Lab selected an approach that replaced much of the digital electronics in the Micro-TSMD with a single ASIC and more memory was added. A new program was created to develop the Micro-TSMD with the parallel interface. The Statement of Work for the Micro-TSMD Development Program was modified to reflect this change of plans. Due to lack of funds no Production Prototype Micro-TSMDs were built.

Appendix A

Lessons Learned

The Honeywell efforts in Time Stress Measurement Devices began about 1985 with the first contract for prototype units in its Military Avionics Division. TSMD technology at that time was new and the applications were just starting to be visualized and requirements were not well defined. From this beginning Honeywell began supporting Rome Laboratory contracts in an effort to develop the technology and expand the applications for TSMD devices.

This Micro-TSMD contract was awarded in 1989 following the completion of a previous contract awarded as a TSMD design definition effort. This initial contract formulated much of the design for this contract and only minor technology changes were planned in moving the device design to preproduction status. This contract was intended to be a predecessor for production unit contracts. Changes in requirements, changes in technology, changes in performance, and cost increases as a result of this were all part of the program as it evolved from initial concept and design to final deliverable product. Changes in the requirements increased the hardware and software both of which added to the hardware constraints and the memory requirements. These added to the size and modified the original design and rationed initial hardware performance and memory capacity to where daughter boards needed to be attached to add components on an already overpopulated ceramic hybrid. While all this was happening there remained the need to maintain a schedule to assure that devices would be available for the intended fielding applications at the promised time.

As the result of these efforts, a number of lessons were learned in the process. These are summarized below.

A.1 Performance Requirements need to be well defined.

This initial program was defined by a statement of work but as the contract proceeded the TSMD design began to be embroiled in controversies of whether it was a logistics tool or an analysis tool. Each of these interests lobbied for the TSMD to best serve their needs. As this continued the software and design become more complex and the schedule for remaining performance got shorter and the unit cost rose significantly.

A.2 Define devices for specific applications rather than for generalized use.

The TSMD evolved as a compromise design. A device for a specific propose may be simple but generalizing the design creates complexities and may increase the size and cost. If a specific need can be determined it is probably cheaper to make the design application specific if quantities above a few dozen are going to be built.

A.3 Keep cost in mind if the device is intended for volume production.

Technical niceties may look and sell good until the realization of the cost denominator is determined. Tradeoffs need to be considered in terms of final cost if the device is intended for volume production. It may be better to make different type units for specific applications rather than a generalized unit.

A.4 Separate the research and design from the production.

Devices developed as research projects can utilize the latest available technology but this technology may not be available to be used in a production environment. A design tolerance task which is usually part of a production effort is needed to assure that each unit can be built without having to be individually optimized or "tweaked" to meet the requirements. Designs by research

facilities need to be disciplined by the structures of a production facility if a volume build is intended. The omission of a single part suffix letter in a Micro-TSMD parts procurement resulted in the real time clock piece part being a commercial temperature range device than full mil temp range device. The result was that all units had to be retrofitted.

A.5 Optimize The Technology for the Time.

Technology is fast moving. The Micro-TSMD utilized technology from 1989 that had matured to guaranteed full mil temperature range performance. Some of these parts are no longer available and thus, the building of additional devices to the same design documentation would be difficult or even impossible. It is important that the production time schedule be considered when selecting the technology of the components, and that the interchangeability or potential for substitution be considered. An example of the unavailability of a component is the serial RAM used in the Micro-TSMD. This device is no longer available thus requiring a design change for production of the TSMD.

A.6 Building and Testing a Broadboard to Reduce Risk and Assure Performance.

A thorough testing of a system design and its components to the system requirements over the operating range is mandatory. Simulations serve as an initial design verification tool and differences may be noted between the breadboard test results and the final hardware, but if the system works as a breadboard it probably will work in the final design or it can be made to work with some minor modifications, but if it doesn't work satisfactorily as a breadboard it probably won't work satisfactorily as a final system. With significant size reduction being experienced in systems using state of the art technology, it is becoming difficult if not impossible, and very expensive to make modifications in final hardware of microelectronics systems. There is always a tendency as program schedules shorten to take shortcuts and eliminate or reduce breadboard activities and go to the final product. This can be fatal or very expensive at best if changes are necessary.

Appendix B

Acronyms

A/D	Analog to digital converter
ADC	Analog to digital converter
ASIC	Application specific integrated circuit
BIT	Built in test
CMOS	Complimentary metal oxide silicon semiconductor type
CND	Cannot duplicate
DMA	Direct memory access
DEG	Degrees
EEPROM	Electrically erasable programmable read only memory
EPROM	Erasable programmable read only memory
ESC	Escape
FFT	Fast Fourier Transform
G	Unit of acceleration (gravity)
G^2/HZ	Unit of measure of power spectral density of acceleration
GND	Ground
HSF	Host fault record
JTAF	Joint Test Access Group
kHz	Kilohertz
LRM	Line replaceable module
LRU	Line replaceable unit
MHz	Megahertz
Min	Minute
ms	Millisecond
MTBF	Mean-Time-Between-Failure
mW	Milliwatt
NC	No connection
RAM	Random access memory
RETOK	Retest OK
RMS	Root mean square
RS-232	Communication interface protocol
RTC	Real time clock
RXD	Receiver port
SRA	Serial random access memory
TSD	Time stamped data
TSMD	Time Stress Measurement Device
TTL	Transistor-transistor logic
TXD	Transmit port
UART	Universal asynchronous receiver transmitter
UTSMD	Micro-TSMD
uW	Microwatt
VREF	Voltage reference

☆U.S. GOVERNMENT PRINTING OFFICE: 1994-610-126-50101

MISSION

OF

ROME LABORATORY

Mission. The mission of Rome Laboratory is to advance the science and technologies of command, control, communications and intelligence and to transition them into systems to meet customer needs. To achieve this, Rome Lab:

a. Conducts vigorous research, development and test programs in all applicable technologies;

b. Transitions technology to current and future systems to improve operational capability, readiness, and supportability;

c. Provides a full range of technical support to Air Force Materiel Command product centers and other Air Force organizations;

d. Promotes transfer of technology to the private sector;

e. Maintains leading edge technological expertise in the areas of surveillance, communications, command and control, intelligence, reliability science, electro-magnetic technology, photonics, signal processing, and computational science.

The thrust areas of technical competence include: Surveillance, Communications, Command and Control, Intelligence, Signal Processing, Computer Science and Technology, Electromagnetic Technology, Photonics and Reliability Sciences.